IMPACTS OF CLIMATE CHANGE ON THE LIVELIHOODS OF FARMING COMMUNITIES ADJACENT TO PROTECTED AREAS: A CASE OF TARANGIRE NATIONAL PARK, TANZANIA

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2019

CERTIFICATION

The undersigned certifies that he has read and hereby recommended for acceptance by Open University of Tanzania, a Dissertation titled: Impacts of Climate Change on the Livelihoods of Farming Communities Adjacent to Protected Areas: A Case of Tarangire National Park, in partial fulfillment of the requirements for the Degree of Master of Arts in Natural Resources Assessment and Management of the Open University of Tanzania.

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Dr. Reguli Mushy

(Supervisor)

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Date

DECLARATION

I, Halid Jumanne, do hereby declare that this dissertation is my own original work and that it has not been presented and will not be presented to any other University for a similar or any other Degree Award.

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Signature

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Date

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DEDICATION

I would like to dedicate this work to my parents, the late mother Bitizan Hussein Mfinanga and my father Jumanne Hamisi Mngofi, my wife Mary Patrick Dello, my two sons Shaith Halid Mngofi and Ibrahim Halid Mngofi and my only daughter Shazma Halid Mngofi.

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ABSTRACT

This study aimed to assess climate change impacts on farming communities' livelihood adjacent to Tarangire National Park. Random sampling without replacement technique was employed to obtain the sampling unit. Questionnaires, field observation, Focus group discussion and key informantsô interviews were conducted to obtain information from the respondents. Data was collected and analyzed by using IBM SPSS version 20 and results presented in tables and bar graphs. The study findings revealed that majority of the respondents perceived climate as prolonged drought and decrease of the rainfall. Also, they reported deforestation and agriculture activities as the major causes of climate change and high temperature, shortened growing season and decrease in productivity as the indicators of climate change. Analysis of weather trend shows insignificant decrease of total annual rainfall (R^2 =0.1798) at 95% confidence level. The average monthly rainfall showed that, the area is characterized by semi-arid climate which is characterized by a prolonged dry condition with a bimodal rainfall type. The results found significant trends for mean maximum temperature on annual basis (R^2=0.5678) at 95% confidence level. On the other hand, insignificant trend was observed in mean minimum temperatures on annual basis where R^2=0.3378 at 95% confidence level. This study concluded that, climate change impacts to the livelihood of communities surrounding Tarangire NP are real due to the decrease in agriculture productivity. The study recommends awareness raising to the public about climate change and its impacts, conservation and proper management of the communities' forests and provision of improved seeds to farmers that have shorter growth periods and thrive well under harsh climatic conditions to provide high yields.

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LIST OF ABBREVIATIONS

CO_2	Carbondioxide
DFID	British Department of International Development
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GCMs	Global Climatic Models
GHG	Green House Gases
IDBWB	Internal Drainage Basin Water Board
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
MDGs	Millennium Development Goals
PAs	Protected Areas
PRA	Participatory Rural Appraisal
SCIP	Support for Community Initiated Project Programme
SLA	Sustainable Livelihood Approach
SLF	Sustainable Livelihood Framework
TANAPA	Tanzania National Parks
TMA	Tanzania Meteorological Agency
TME	Tarangire - Manyara Ecosystem
TNP	Tarangire National Park
UNEP	United Nation Environmental Programme
UNWTO	United Nation World Tourism Organization

URT	United Republic of Tanzania
WHO	World Health Organization
WWF	World Wide Fund for Nature

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Research Problem

The dynamic interaction between the atmosphere, oceans, cryosphere and the terrestrial and marine biospheres determines the global climate at the Earthôs surface (Githeko *et al*. 2000). The increasing accumulation of greenhouse gases in the global atmosphere and increasing regional concentrations of aerosol particulates are now understood to have detectable effects on the global climate system (Sivakumar *et al.* 2005).

Scientists believe that changes in the atmospheric composition due to increasing concentrations of greenhouse gases (mainly carbon dioxide, methane and nitrous oxide), changes in land cover and agricultural activities are responsible for warming the earth surface, causing global increases in temperature (IPCC, 2007; Yanda and Mubaya, 2011; Omambia *et al*. 2010). Although there are still debates among scholars with regard to whether climate change is induced by anthropogenic activities or is as a result of natural climate variability, the balance of scientific opinion is that changes in the composition of the atmosphere are attributed to human activities that lead to global warming (IPCC,2001; 2007; 2014).

However, the IPCC Report (2014) showed that the total anthropogenic GHG emissions have continued to increase from 1970 to 2010, with the highest amount noted between 2000 and 2010. The report further notes that the release of carbon dioxide into the atmosphere from the burning of fossil fuels and industrial activities contributed about 78% of the total GHG emissions from 1970 to 2010, with a similar

increase from the period 2000 to 2010 (IPCC; 2001; 2007). The rising temperatures heat the land mass and the surrounding oceans, causing increases in surface temperatures and changes in precipitation, which are important drivers of global climate change (Collier *et al*. 2008; Challinor *et al*. 2007). Whilst the trends and patterns of climate change projections are generally consistent, they are subject to varying degrees of uncertainty due to limitations in measurements and knowledge of the interactivity between earth systems (Challinor *et al*. 2007; Adger *et al*. 2003).

According to the recent report issues on Monday October 8, 2018 by the UN intergovernmental Panel on Climate Change, the planet will reach the crucial threshold of 1.5 ^{o}C (2.7 degrees Fahrenheit) above pre-industrial levels by as early as 2030, precipitating the risk of extreme draughts, wildfires, floods and food shortage of hundreds millions people. Changes in temperature and precipitation also are projected to influence extreme weather events (floods, drought and storms); affect food production (availability) and prices; water availability and access; nutrition and health status (FAO, 2008; IPCC, 2007; Omambia *et al*. 2010).Therefore, the socioeconomic impacts are likely to be significant and will impact humans through a variety of direct and indirect ways (Heltberg *et al*. 2009; IPCC, 2007).

Generally, the impacts of climate change are projected to have enormous and devastating global consequences on the global scale, but the most adverse impacts are predicted to occur in developing countries due to their fewer resources to cope with, and adapt to, the changing climatic conditions, which is due to their geographic location (within vulnerable and fragile environments) and their over-reliance on rain-fed agriculture, which is a climate-sensitive sector (Stern, 2007; IPCC, 2007;

Omambia *et al*. 2010). Based on the recent report, the planet is already two thirds of the temperature increase warmed about 1 degree centigrade. Avoiding going even higher will requires significant actions in the next few years to lower emissions through changes in energy, industry, buildings transportations and cities.

Africa is highly vulnerable to climate change impacts with less adaptive capacity due to poverty inter alia (IPCC, 2001). Climate change in Africa vary from humid equatorial regimes, arid and semi-arid regimes to sub-tropical Mediterranean-type climates with different degrees of temporal variability in rainfall and temperature (Hulme *et al*. 2001; Collier *et al*.; 2008, Haile, 2005). Climate change is expected to make some regions wetter (such as the eastern parts of Africa), while other regions like the southern and northern parts of Africa will get drier and more adversely affected by the changes(Collier *et al*. 2008; Hulme *et al*. 2001).The United Nations World Tourism Organization studies recognize the impacts of climate change and variability on socio-economic sectors globally, and specifically on Tourism (UNWTO, 2008).

In Tanzania, climate change impacts are evident almost everywhere and has caused adverse impacts on peopleôs livelihood and in the economic sectors including farming and livestock keeping (URT, 2007). Tanzaniaôs economic base is dependent on the use of natural resources, rain-fed agriculture and biomass for household energy (IPCC, 2001; 2007). Therefore, the community livelihoods are highly vulnerable to the adverse impacts of climate change and to extreme weather events. Climate change poses a serious risk to poverty reduction efforts in the country by threatening decades of development efforts especially the National

Development Vision 2025 and Millennium Development Goals (MDGs) (URT, 2005). Past trends of drought and flood for instance, has resulted into poor harvests in 2005 that caused hunger in most parts of the country (WHO, 2007).

Protected areas serve as natural buffers against climate change impacts and other disasters, providing space for floodwaters to disperse, stabilizing soil against landslides and blocking storm surges (IUCN, 2008). Protected areas can keep natural resources healthy and productive and continue to provide food, clean water, shelter and income to communities that rely upon for survival (https://www.iucn.org/downloads/solutions.pdf) Tarangire National Park (TNP) being one of the protected areas in Tanzania is characterized by scattered baobab trees, acacia woodland that caters for wildlife food, open bush plains, swamps and river. This park jointly together with Lake Manyara National Park (LMNP), Manyara Ranch and surrounding areas constitute to Tarangire ï Manyara Ecosystem (TME).

The TME has experienced climatic variations attributed to the effects of climate change including delays in the onset of rainfall, shorter rain seasons, prolonged dry seasons, early rainfall recession and unpredictable rainfall patterns. Tanzania.org/images/Final_report_launch_vs_3.pdf). These observations coupled with growing human population, large scale farming and other economic land uses have impacted biodiversity as well as adjacent communities' livelihoods. The sustainable conservation of the TNP is potentially depending on the sustainable management of surrounding areas and associated habitats (TANAPA, 2002).

1.2 Statement of the Research Problem

The frequency and severity of extreme climatic changes such as droughts, flood and extreme temperatures have been confirmed in Manyara Region and 70% of all-natural disasters are hydro-meteorological (URT, 2007). Within TME, changes in rainfall intensity, erratic and unreliable rainfall patterns and prolonged dry seasons have been obvious in recent years impacting water quantity in the river catchment and poses enormous effects to communitiesô livelihoods and wildlife.

While people in rural areas highly depend on rain- fed agriculture and livestock keeping for their livelihoods, climate change has imposed significant impacts to their economic activities. As a result, people are eager to implement adaptive strategies to reduce the negative impacts of climate change. Despite of the recent efforts dedicated by many scholars on climate change issues, very little concern have been addressed and documented on such impacts to communities' livelihood. Therefore, this study focuses on assessing climate change impacts on the communitiesô livelihoods surrounding Tarangire in order to recommend possible mitigation measures and adaptation strategies for sustainability of both local communities and the park.

1.3 Objectives

1.3.1 General Objective

The general objective of this study is to show the impacts of climate change on the communitiesô livelihoods surrounding National Parks.

1.3.2 Specific Objectives

1. To examine climate change perceptions of the local communities around

TNP

2. To assess trends of climate over the past 40 years around TNP
3. To examine the trends of agricultural productivity of the local communities surrounding TNP over time

1.4 Research Questions

1. What are the perceptions of local communities around TNP on climate change?
2. What is the trend of climate for the past 40 years around TNP?
3. What is the trend of agricultural productivity for local communities around TNP over time?

1.5 Significance of the Study

Tarangire - Manyara Ecosystem is exceptionally important for wildlife conservation in Northern Tanzania and potential tourism zone which in turn supporting livelihoods of surrounding local communities. However, human activities around TNP and other factors threaten long-term sustainability of the park, which also in turn impact the livelihoods of the adjacent communities. This study will add knowlegde on the climate change perceptions of the local communities, signifies impacts to them, and produce evidence of the climate change to communities around TNP. As far as climate change is a worldwide agenda this study will help to inform decision makers in national and international levels. Furthermore, the results will contribute to the body of knowledge on the impacts of climate change to the livelihoods of the communities adjacent to wildlife protected areas and inform policy makers to timely consider and act to mitigate impacts for sustainable rural

livelihoods.

1.6 Limitation of the Study

Several limitations were encountered during this study research. At first the respondents were so scared to give out information because they were afraid that the researcher was sent by the government to see if there is a possibility of expanding National park. Later on the researcher clarified the purpose of the study and to the respondents and they finally participated well. Another limitation encountered was availability of the respondents in the household. Majority of the respondents were not found in their settlements until late evening because of water shortage problem. The communities spend most of their time searching for water in distant areas. The researcher then used evening time to visit household and the exercise was successful.

1.7 Structure of the Dissertation

This study is organized into five major chapters. Chapter one describes the research context in the form of introduction. Specifically, it provides the background to the study states the problem and presents the objectives and the significance of the study. Chapter two reviews literature related to climate change perception trends and agricultural productivity. Chapter three presents the methodology employed in this study in particular; it presents the background of the study area, research design, methods, data analysis, variability/reliability and ethical consideration.

The description of the study areas focuses on the location of the study villages, the biophysical environment and the socio-economic context whereas the methodology part describes the research design, sample size and sampling procedure, data

collection methods and data processing and analysis. Chapter four analyses and presents the results in addition to discussing the key findings of the study. Chapter five presents the main conclusions of the study and recommendations for policy-making by assisting community members to develop informed understanding of climate change trends, impacts, consequences and maximizing opportunities for citizens and communities to effectively contribute to public debate on climate change issues and actions.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews literatures related to climate change impacts on communitiesô livelihoods. It provides global, regional and country overviews of current and future climate change and adaptation strategies to curb the existing impacts for sustainable community livelihood. It also analyses the perception on climate change among local communities. It further examines trends of rainfall and temperature over the past 40 years in areas adjacent to protected areas as evidence of climate change. The reviews further assess the agricultural productivity trends of the local communities surrounding study area over time and potential adaptation strategies taken by communities in face of climate change around protected areas. Based on the shortcomings of the literature, the chapter finally presents research gap and conceptual framework

2.2 Definition of Key Terms

2.2.1 Climate Change

Climate refers to statistical description in terms of means and variability of key weather parameters for a given area over a period of time usually at least 30 years. According to Intergovernmental Panel on Climate Change (IPCC), climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2007). It can be a change in the average weather or a change in the distribution of weather events around an average (for example, greater or fewer extreme weather events). Such changes may be limited to a specific

location, region, or may occur across the whole Earth.

2.2.2 Protected Areas

Protected area is defined as geographical space that is recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values (IUCN, 2008). Protected areas include: national parks, wilderness areas, community conserved areas, natural reserves and antiquities sites. These areas are mainstay of biodiversity conservation and contribute to peopleôs livelihoods. Protected areas are at the core of efforts towards conserving nature and the services it provides us with food, clean water supply, medicines and protection from the impacts of natural disasters. Their role in helping mitigate and adapt to climate change is also increasingly recognized.

2.2.3 National Park

National park is a conservation entity established under National Parks Ordinance Cap 412 of 1959, with a legal mandate of preserving both natural and cultural resources of the country (IUCN, 1994). Only non-consumptive tourism, education and research are permitted in the national parks (TANAPA, 2008).

2.2.4 Community and Local Community

Mattessich and Monsey (2004) define community as people who live within a geographically defined area and have social and psychological ties with each other and with the place where they live. Business Dictionary (2014) defined local community as a group of individuals that interact within their immediate

surroundings. A typical local community consists of business operators, public agency staff and residents, and their interactions can include the sharing of resources, information and assistance, as well as the establishment of commercial relationships between local businesses and consumers.

2.2.5 Livelihoods

Livelihood is a means by which a living is secured. According to Chambers and Conway (1992) a livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. It comprises the activities, the assets and the access that jointly determine the living gained by an individual or household. Also, according to Ellis (2000) livelihood consists of assets (natural, physical, financial, human and social capital), the activities and access to these (mediated by institutions and social relations) that, together, determine the living gained by the individual or household. Access to assets, for example land, together with the crop production activities and other income generating activities, determines the living gained by a household or an individual.

2.2.6 Households

The 2012 Population and Housing Census (PHC) for United Republic of Tanzania define households as a person or group of persons who reside in the same homestead or compound but not necessarily in the same dwelling unit, have the same cooking arrangements, and more answerable to the same household head. A single dwelling will be considered to contain multiple households if either meals or living space are not shared. The household is the basic unit of analysis in many social,

microeconomic and government models, and is important to the fields of economics, inheritance. Household models include the family, varieties of blended families, share housing, group homes, boarding houses and houses in multiple occupations.

2.3 Theoretical Review

Parks and protected areas provide a unique opportunity for users to experience many aspects of their lives in a natural setting. However, it is this need of users to experience those personal aspects which is providing parks and protected areas with their largest natural threats (Dearden & Rollins, 2002). Climate change has always threatened long-term sustainability of protected areas due to human based activities conducted adjacent to it. Through climate change and local community, there are various theories / approach or model including the sustainable livelihood approach which can be used in research to better understand the general concept when the local communities are trying to overcome the impacts of climate change.

2.3.1 Sustainable Livelihood Approach

The concept of ósustainable Livelihoodsô constitute the basis of different ósustainable Livelihood Approachesô (SLA) and has been adapted by different development agencies such as the British Department for International Development (DFID). The DFID has developed a ósustainable Livelihood Frameworkô (SLF) which is one of the most widely used livelihoods frameworks in development practice. The SLF was integrated in its program for development cooperation in 1997. DFID adapts a version of Chambers Conwayôs definition of livelihoods: ñA livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses

and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource baseò (DFID, 2000).

DFIDôs biggest aim is the elimination of poverty in poorer countries. DFID, however, stresses that there are many ways of applying livelihoods approaches. Although the application of the livelihoods approach is flexible and adaptable to specific local settings and to objectives defined in participatory manner, it underlies a couple of core principles. The Sustainable Livelihoods Approach (SLA) is often proposed to holistically capture vulnerability in assessments of livelihoods in aid and development programs. The full capacity of the approach has however only rarely been used in these assessments, lacking a clear account of processes of change and flexibility of assets, as well as the ability to quantify all capital assets of a livelihood system. The descriptions of livelihoods so far are in fact non-holistic.

Due to growing evidence that impacts of climate change will increase already in the near future, and that the poor populations of the world will be more severely affected than others, the interlinked concepts of vulnerability, adaptation and resilience have simultaneously found their way into climate change and development discussions(c.f. Kelly & Adger, 2000; Adger *et al*. 2003). A number of scholars are currently advocating an asset-based approach in general and a Sustainable Livelihoods Approach (SLA) in particular, as a framework with the potential to guide holistic and integrated assessments of vulnerability to multiple stressors (Kelly & Adger, 2000). Such an asset-based approach is rooted in a ñbottom-upò perspective that starts from understanding how resources are mobilized on the local level, rather than predicting impacts of specific changes at regional, national, or even

global level.

The livelihoods concept has been inconsistently applied in research on human dimensions of global environmental change, resulting in limited understanding about how development programs and policies influence adaptive capacity. Sustainable livelihoods analytical frameworks can help visualize complex adaptation pathways, illuminating how households and individuals come to differ in their capacities to adapt to climate change. Sustainable livelihood approach is flexible design and openness to changes and can fit to diverse local contexts. It might serve as an analytical tool in order to identify development priorities and new activities prior to any development activity.

Further, the SLA might be used as a checklist or means of structuring ideas or can be applied in the form of a livelihood analysis to assess how development activities ófitô in the livelihood of the poor (Kollmair *et al*. 2002). In addition, SLA does not contradict to other current development approaches, rather tries to combine and take advantage of their strengths. It relies on participation and pays special attention to gender specific or ecological issues. A livelihood analysis therefore applies a broad range of conventional methods and instruments, as for example from Participatory Poverty Assessment (PPA), Participatory Rural Appraisal (PRA) and Good Governance Assessment techniquesò (Kollmair *et al*. 2002).

However, the SLA analysis needs time, financial and human resources. The claim of being holistic inevitably delivers a flood of information hardly possible to cope with. Additionally, by improving the livelihoods of a specific group a negative effect may

occur on livelihoods of others. This may lead to a normative dilemma on the decision about what to consider with priority. Reducing the livelihood perspective to a methodological tool contains the risk to look at the two things interchangeably.

2.4 Empirical Literature Review

The empirical literature review aims to provide new knowledge on a topic throughout as the literatures, or previous studies that relate to the impact of climate change on the livelihood of farming communityôs adjacent protected areas.

2.4.1 An Overview of Current and Future Climate Change

Climate change can have significant negative impacts on the natural environment including the loss of biodiversity and changes in ecosystem (IPCC, 2007). Climate change is largely attributed to changes in atmospheric concentrations of greenhouse gases and aerosols, in solar radiation and in land surface properties. Since pre-industrial times a marked increase has been noted in the atmospheric concentration greenhouse gases such as carbon dioxide, methane and nitrous oxide primarily due to human activities such as fossil fuel burning, land use changes and agricultural activities. This has resulted in the alteration of the energy balance of the climate system and manifesting as increases in temperature, changes in rainfall patterns, and more frequent and severe extreme events among other effects (IPCC, 2007b). An increase in the frequency and intensity of extreme events has been noted since the last century.

According to observations reported by the IPCC (2007b), the lower atmosphere is warming up faster than anticipated and an increase in global surface temperature of

about 0.76^0C has been noted between 1850-1899 and the 2001-2005. A warming of 0.2^0C is projected for the next two decades at a rate of about 0.1^0C per decade. Trend in precipitation over the 1900-2005 periods showed an increase in the eastern parts of North and South America, Northern Europe and Northern and Central Asia and a decrease in Sahel, the Mediterranean and Southern Africa.

Future precipitation projections suggest a high likelihood of increases in the higher latitudes and decreases in subtropical regions. Overall it is projected that the increasing concentration of greenhouse gases would result in several changes in the global climate system over the course of the 21st century that are expected to be larger than those observed over the 20th century (IPCC, 2007a). Africa is one of the most vulnerable regions in the world to climate change mainly due to poverty, lack of awareness, lack of access to knowledge and a high dependence on natural resources and rain-fed agriculture. About 70% of people in Africa especially in rural areas solely depend on Agriculture for their livelihood, while 40% of all exports are of agriculture produce (Mugabe et al. 2000; McCarthy *et al*., 2001; IPCC 2001; WWF, 2002).

The historical climate record for Africa shows increased warming rates since the 1960s with a warming of approximately 0.7C over most of the continent noted during the twentieth century. A decrease in rainfall over large portions of the Sahel (the semiarid region south of the Sahara) and an increase in rainfall in east and central Africa has also been observed (WWF, 2002). This is already impacting critical sectors such as water resources, food production, human health and biodiversity and resulting in increased desertification trends across the

continent(IPCC, 2007a; McCarthy et al. 2001).

In Tanzania climate change impacts are evident almost everywhere and has caused adverse impacts in peopleôs livelihood and in the economic sectors including farming and livestock keeping (URT, 2007). A number of studies conducted recently in Tanzania have recognized that climate change and variability is happening and is coupled with significant impacts on natural resources and agriculture which is the main source of livelihood in rural areas (Agrawala *et al*. 2003; Majule, 2008). The wide global climate change trends are greatly reflected in Tanzania's climate. Because of her geographical location and the topographical characteristics, the country offers the best opportunity to study and further understand global climate trends. Deteriorating water quality and quantity, loss of biodiversity and declining agricultural productivity due to climate change, are threats that have already materialized and caused Tanzanians repeated misery (Yanda, 2005).

Regardless of her low level of development, Tanzania also contributes to global warming mainly through deforestation, large animal herds and overgrazing, mining activities, industrial and vehicular air pollution, land use changes and poor waste management and disposal. However, Tanzaniaôs contribution to causes of climate change is very low in comparison to other countries. In terms of contribution by sector, land use changes in the country contributes more to the problems than fossil fuel emission primarily because of its low level of development. Thus, effort to combat climate change in the country will have to focus more on land use change sector (UNEP, 1999).

2.4.2 Climate Change Impacts on Agriculture Productivity

Agriculture is highly sensitive to climate variability and weather extremes, such as droughts, floods and severe storms. The increased potential for droughts, floods and heat waves pose challenges to farmers and the enduring changes in climate, water supply and soil moisture affects farm productivity (IPCC, 2007). Further changing rainfall patterns will affect the amount of water available for food production. Climate change poses a significant threat to the food security and livelihoods of hundreds of millions of people who depend on small-scale production from crops, livestock, fisheries and forests (FAO, 2009).

In addition to primary agricultural production, climate change will affect the ecology of beneficial and pest organisms altering their abundance and distribution in space and time (IPCC, 2007). The health of animals and humans will also be threatened; this will increase the burden and vulnerability to the poor livelihood and jeopardize poverty alleviation strategies. The yield for the most important agricultural crops are expected to declines and result in additional price increase for crops such as rice, wheat, maize, and soybeans (Stern, 2006a.). Also higher feed prices will result in higher meat prices and reduce the growth in meat consumption slightly and cause a more substantial fall in cereals consumption(Stern, 2006b; Paul *et al*. 2009).

According to IPCC 2007 by 2050, the decline in calorie availability will increase child malnutrition by 20 percent relative and climate change predicted to eliminate much of the improvement in child malnourishment levels that would occur with no climate change. Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation patterns

increased the likelihood of short-run crop failures and long-run production declines (IPCC, 2007; Ngusaru, 2007). Although there will be gains in some crops in some areas of the world, the overall impacts of climate change on agriculture are expected to be negatively threatening global food security. More favorable effects on yield tend to depend to a large extent on realization of the potentially beneficial effects of carbon dioxide on crop growth and increase of efficiency in water use. Decrease in potential yields is likely to be caused by shortening of the growing period, decrease in water availability and poor adaptation capacity (IPCC, 2001a; Gwambene, 2007).

In the long run, the climatic change affects agriculture productivity, in terms of quantity and quality of crops; agricultural practices, through changes of water use (irrigation) and agricultural inputs such as herbicides, insecticides and fertilizers (FAO, 2003, Burton *et al*. 2010). Also production are affected through environmental effects, particularly in relation of frequency and intensity of soil drainage (leading to nitrogen leaching), soil erosion, reduction of crop diversity; rural space, through the loss and gain of cultivated lands, land speculation, land renunciation, and hydraulic amenities and adaptation.

2.4.3 Effects of Climate Change on Precipitation

According to the World Meteorological Organization (in Henson, 2011) estimated deaths of more than a million people in African Sahel occurred in 1972-1975 and 1984-1985 due to a devastating drought (rainfall was estimated to have declined by about 30% in 1984/1985). The current rainfall data indicate a gradual increase in precipitation in the Sahel region, especially in the years 1994, 1999 and 2003 which received more rainfall than before 1970, while other years have remained dry,

occasionally caused by strong El Niño conditions such as in 1997/1998 (Henson, 2011). The reduction of, and variability in, rainfall and increases in temperature will worsen food security in the region, and consequently affect the livelihoods of the majority of subsistence farmers and pastoralists whose lives depend critically on rainfall (Haile, 2005).

In general, an increase in temperature will affect and modify rainfall intensity, evaporation rates, run-off and soil moisture storage (Rosenzweig and Hillel, 1995), which will affect crop yields negatively because many crops in Africa are grown close to their thermal tolerance threshold limits (Henson, 2011; Collier *et al*. 2008; Rosenzweig and Hillel, 1995). Increased heat and drought will stress crops by limiting transpiration resulting in a rise in plant temperatures which will affect the flowering, pollination and grain-filling of those crops which are most sensitive to water and heat stress conditions. Such crops include wheat, groundnuts, soybean, maize and fruit trees (Collier *et al*. 2008; Rosenzweig *et al*. 2001). Indeed, under intensified and prolonged drought conditions some of the regions may become unsuitable for farming activities. This will cause a reduction in farming land and/or a reduced length of growing season, as well stopping the production of some food crops and prompting food shortages (Collier *et al*. 2008), and search for other alternative food crops.

2.4.4 Effect of Climate Change in Temperature Variability

Increase in surface temperatures will increase soil temperatures which will in turn affect plant metabolism through the degradation of plant enzymes, limiting photosynthesis and affecting plant growth and yields (Sivakumar *et al*. 2005). Soil

temperature increase elevates evapo-transpiration which may cause damage especially to those crops with surface root systems utilize mostly precipitation moisture. A study by Arndt *et al*. (2012) on the impacts of climate change on crops production in Tanzania revealed that maize yields in the northern part of Tanzania increased substantially during the wet season and decreased by similar amounts in the hot and dry seasons. The study suggested that, maize yields are favored under cool and wet scenarios; hence they projected only a very small increase in yields in those regions under hot and dry scenarios.

The projected increases in temperature, along with increased rainfall variability may affect crop yields especially when fluctuations occur at the different stages of crop development (germination, growing, flowering and ripening/harvesting stages), while a combination of higher precipitation with higher temperature may accelerate crop death (Rosenzweig *et al*. 2001). Also, a study conducted by Kangalawe (2012) in the southern highlands of Tanzania suggested that, a higher reliance on weather for agricultural activities has occasionally subjected the country to food shortages and insecurity especially more in years with low rainfall.

2.4.5 Effect of Climate Change on Livestock Production

Rising temperatures and declining rainfall will affect livestock in Africa, where two-thirds of domestic livestock are herded through nomadic systems, although significant numbers are also kept under zero-grazing conditions, by reducing the availability of fodder and drinking water, and through increased heat stress. Also, in some areas a significant share of fodder comes from crop residues, hence the declining agriculture will also affect livestock farming in many parts of Africa

(Sivakumar *et al*., 2005). Similarly, increased warm conditions will favor the increased distribution, incidences and intensity of diseases such as rift-valley fever, rinderpest and tick-borne diseases, which will attack livestock and also reduce suitable rangeland area for nomadic livestock herding (FAO, 2008).

According to FAO (2008), the changing conditions will increase animal diseases and/or newly emerging diseases, particularly in Africa, which is already undergoing an enormous burden of animal disease. Thornton *et al*. (2006) states that, increasing drought conditions in East Africa will reduce water availability and increase infections rate due to increased interactions between livestock and wildlife. However, the IPCC report argues that, due to the effects of climate change, the 21st century is projected to experience increases in ill-health in many regions, and particularly in developing countries with low incomes as compared to a baseline without climate change (IPCC, 2014).

2.4.6 Climate Change Impacts on Livelihoods in Africa

The community livelihoods in Africa highly depends on agriculture as its single largest economic sector, employing about 60% of the population and contributing to about 50% or more of the gross domestic product (GDP) of most African countries (Collier *et al*. 2008). The same contributes to development as an economic activity supporting community livelihood and providing ecosystem services (World Bank, 2008). Most importantly, the sector is also responsible for providing food security from domestic production for both rural and urban populations (Tingem *et al*. 2009; Bryceson, 2000), where production is determined by rainfall, and hence so is the economic and social wellbeing of the community (Haile, 2005; Adger *et al*. 2003).

Agriculture supplies up to 50% of household food requirements and up to 50% of household income. However, agriculture and agro-ecological systems in general are most vulnerable to climate change, especially in Africa. Food production in most of sub ï Saharan Africa has been on the decline, and has not kept pace with the current population growth.

The main effect of climate change on semiarid and tropical agro-ecological systems is a significant reduction in crop yield, which in Africa, may well force large areas of marginal agriculture out of production. Global warming could reduce rainfall and shorten growing seasons in the tropics to less than the minimum 120 days required for most cereal crops (Devereux and Edward, 2004). Results from recent country assessments show that most of the crops modeled tend to have decreased yields; tropical crops such as grasses, sugarcane, rice, maize, millet and sorghum are particularly vulnerable (Desanker *et al.* 2001)

2.4.7 Perception of Climate Change Impacts by Local Communities

People who depend on natural resources, especially the poorest, are often particularly vulnerable to climate change (Morton, 2007). Understanding on how people experience and respond to such variability to guide climate change adaptation strategies is paramount important. Rural communities especially those living adjacent protected areas already have in depth knowledge of local climate change as part of their traditional ecological knowledge (TEK), i.e., their knowledge, acquired and transferred through generations (Berkes *et al*. 1995, 2000). Here ñlocal perceptionsò refers to the way local people identify and interpret observations and concepts (Byg and Salick, 2009). Even though climate change may bring conditions

beyond previous experience, local knowledge and perceptions remain the foundation for any local response. Most studies on perceptions of climate deal with temperature and rainfall, i.e., amount, annual distribution, start and end dates (Deressa *et al*. 2009, Fisher *et al*. 2010).

Meteorological data are often used to confirm villagersô assessments (Orlove *et al*. 2000, Deressa *et al*. 2009, Fisher *et al*. 2010) or refute them (Maddison 2007; Bandyopadhyay *et al*. 2011) for long-term perceptions. Previous studies have dealt with perceptions of seasonality (Bryan *et al*. 2009, Bandyopadhyay *et al*. 2011), perceptions of risks and threats related to climate variability and Thomas *et al*. 2007, Adger *et al*. 2009; McCarthy, 2011; Saroar and Routray 2012) and local knowledge in forecasting weather and adapting to climate (Orlove *et al*. 2000).

The perception of climate change for farmers' adjacent protected areas was formed as a basis of their beliefs, knowledge and experiences of climate change (Bryant *et al*. 2000) and from this perception; they have adopted new behaviors or innovative practical approaches. Knowledge of adaptation measures taken by local communities against climate-related issues can help policy making decisions on adaptation and climate change mitigation (Berkes, 2001). Climate change is expected to adversely affect agricultural production in Africa.

Because agricultural production remains the main source of income for most rural communities in the region, adaptation of the agricultural sector is imperative to protect the livelihoods of the poor and to ensure food security. A better understanding of farmersô perceptions of climate change, ongoing adaptation

measures, and the decision-making process is important to inform policies aimed at promoting successful adaptation strategies for the agricultural sector. Despite the fact that climatic changes have being occurring over generations, rural farmers have also been adapting to these changes throughout their life by the use of local environmental knowledge (Beckford and Barker, 2007). The knowledge may be relatively cheap, readily available to rural farmers and a climatically smart tool for sustainable development and the management of climate change and variability (Odero, 2011). Rural communities specifically farmers, through continued experimentation, trial and error and sustained interactions with their local environment, have developed a vast local knowledge about nature in their locale that they use in coping with and solving their problems, among which are climate-related problems (Krishna, 2011; Beckford and Barker, 2007).

2.4.8 Adaptation Strategies and Responses to Combat Impacts of Climate Change in Tanzania

Addressing climate change is one thing Tanzania must do. Any successful breakthrough in poverty alleviation in the country will have to include climate change mitigations by the government and its institution, private and public at various levels. Generally, climate change adaptation measures in Tanzania will be different from society to society owing to its geographical, sociological and economical characteristics. Some studies have shown that some societies in Tanzania are already coping with the effects of climate change (Shayo, 2006). However, such adaptation mechanisms are hampered by the severity and the speed of climate change effects.

As the effects of climate change in Tanzania continue to impoverish the population and becomes more severe and of repeated nature, different societies developed or relied on diverse local strategies to cope with the challenge. Most local people find it hard to cope with climate change using modern technologies like high input agriculture and biotechnology due to high cost engaged and has relied on their indigenous skills (Orindi and Murray, 2005). In places where climate change has resulted into repeated agricultural failures, it is common to find members of typical farming villages doing extra farm activities to maximize survival (Shayo, 2006).

Farmers and pastoralists have adapted some local ways of predicting short to long-term climatic changes such as drought. Once the drought is locally predicted, pastoralist would move livestock and/ or shifting herd to safer places to reduce risk. Northern societies for example Barabaig and Maasai living adjacent and within Tarangire-Manyara ecosystem have particularly been involved in transhumance (Paavola, 2003). Repeated occurrence of climate disasters has forced farmers to grow traditionally drought-resistant crops such as sorghum, millet, Sesame, cowpeas and peas (Ibid). Intercropping with the aim of maximizing harvest is currently becoming a common phenomenon.

According to Shayo (2006), it is common to find more than five different crops being grown in a piece of land in the common drought-prone areas. Yet some farmers would open up of large pieces of land for agricultural activities and applying more agricultural inputs in attempting to have better harvest. Places where irrigated agriculture is possible people have been trying to water their crops in the absence of rainfall. Apart from that, some farmers have also changed planting seasons as

affected by potential drought occurrence (Orinda and Murray, 2005).

2.5 Conceptual Framework

The conceptual framework provides the bases for applying subject matter and competence in conjunction with a holistic perception of a livelihood system on sustainability of natural resources utilization. It complements to subject matter based on theories and methodologies for analyzing economic, social, institution and environmental dimensions of development issues (Klasen, 2004; Gwambene, 2017). The guiding assumption of the framework is that people pursue a range of livelihood outcomes by which they hope to improve or increase their livelihood assets and to reduce their vulnerability and sustain their natural resource bases. Human activities, institutional arrangements and natural stressors form an important component in sustainability of livelihood and ecological resources (Spangenberg, 2002). This framework therefore has been applied in investigating the relationship of climate change impacts on community livelihoods adjacent to Tarangire National Park.

Most of the consulted literatures indicated that, climate change is arguably the greatest contemporary threat to biodiversity and livelihood of communities. It is caused by various factors including the rise in concentration of greenhouse gases in the atmosphere, which stem primarily from both natural and human activities. It impacts through temperature rise, prolonged drought, erratic rainfall pattern, stressed water resources and loss of biodiversity which in turn are expected to deepen poverty, food insecurity, poor livelihoods and unsustainable development. Generally, this conceptual framework has been used to guide this study

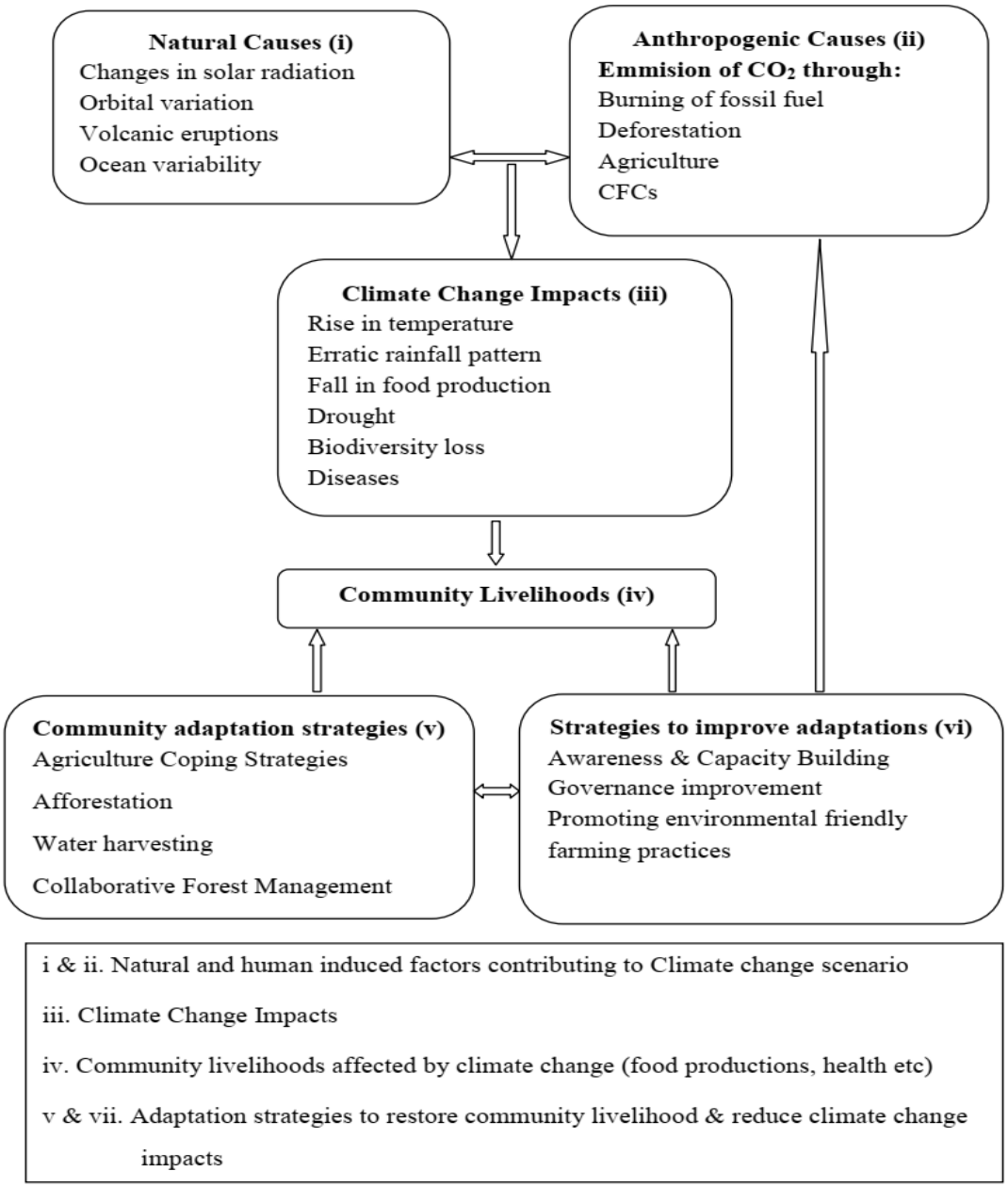

Figure 2. 1: Interrelationship between Climate Change Impacts and Communities' Livelihoods

Source: Boon & Ahenkan, 2012

2.6 Research Gap

Although just very recently recognized as such, protected areas are essential part of the global response to climate change. They play an important role in climate change

mitigation and adaptation by reducing greenhouse gas emissions and helping society cope with impacts of climate change by maintaining essential ecosystem services on which people depends. However, many protected areas in Tanzania are becoming isolated and the reasons for the isolation include rapid population growth with associated economic activities which were previously not earmarked (Newmark, 2008).

Population growth and the resultant human activities generate pressure to the natural and man-made environments (Maduhu, 2004). Communities around PAs and specifically in TNP are experiencing changes in land productivity due to both anthropogenic and natural factors impacting both natural resources and their livelihoods. The issue of climate change impacts on adjacent local communities' livelihood and their perceptions has not been deeply researched. Furthermore, this study will recommends the possible ways that can be used by household to increase their adaptive capacity towards the changing climate in the study area and other areas facing the similar challenges.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the procedures that were followed in conducting this research. It describes the study area, research design and methods used for data collection. It further stipulates methods applied in data analysis and presentation, validity and reliability of the research results and ethical considerations.

3.2 Research Design

Research design is an arrangement of procedures and methods that described exactly what is going to occur in the study (Mwiria and Wamahiu, 1995). It is the conceptual structure within which a study is conducted (Kothari, 2004). It constitutes the blueprint for collection, measurements and analysis of data. Descriptive research design was used to collect information through questionnaire, direct observation, and interviews whereas analytical research was used to collect information already available through documentary review.

Considering the aim and nature of the study, a case study design was employed. According to Gay (1992), a case study is conducted when in depth information is needed to determine the background environment and characteristics of people with problems. This case study enabled the researcher to acquire crucial information on impacts of climate change on the livelihoods of farming communities adjacent to protected areas. In this regard, the case study design matched with the objectives of the study.

3.3 Study Area

3.3.1 Location of the Study Area

This study was conducted in four villages adjacent to Tarangire National Park. The villages involved were Olasit, Kakoi, Vilima Vitatu and Sangaiwe all of them are located within Babati District Council (Figure 3.1). These villages border the park in the north-west section. Tarangire National Park is among the northern Tanzania parks largely located within Manyara Region and its small proportion area administratively falls under Monduli and Kondoa districts in Arusha and Dodoma Regions respectively. The park covers an area of 2,850 km^2 and fall under Tarangireï Manyara ecosystem (TME) covering an area of about 35,000, km^2.

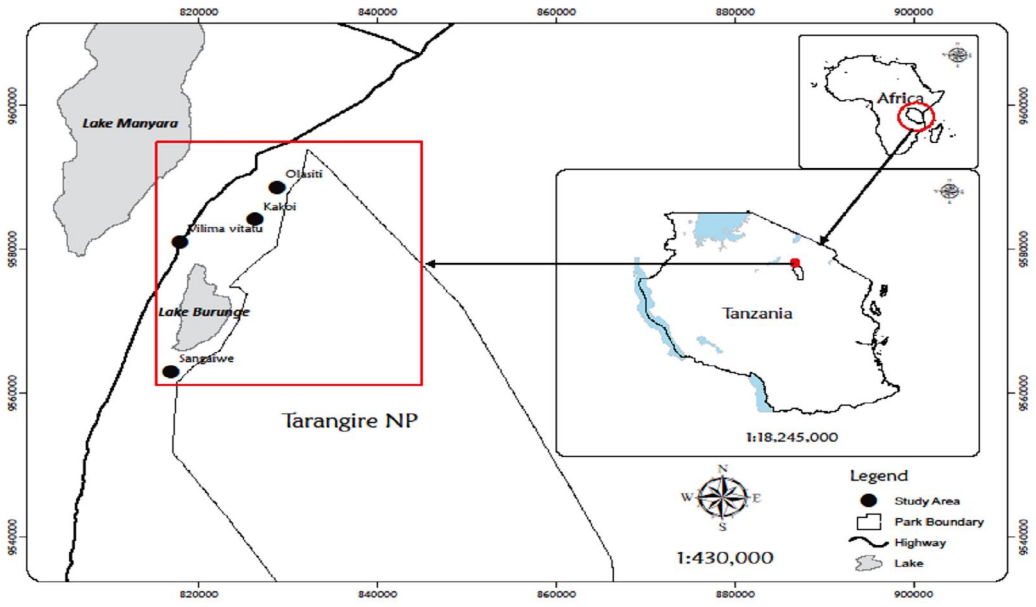

Figure 3. 1: A Map showing location of the Study Site

Source: TNP, 2018

Moreover, the park is characterized by woodland savannah, grasslands, floodplains wetlands and riverine ecosystems (Kahurananga, 1979). The park lies between latitudes 3گ40ôS and 5گ35ôS and longitude 35گ45ô and 37گE at an elevation of

between 1200 and 1600 meters above sea level. The study area was selected based on TNP hydrology characteristics and ongoing economic activities in adjacent areas.

3.3.2 Climatic Characteristics

The TME fall within a semi-arid climate characterized by a prolonged dry season which last up to 7 months with a bi-annual rainfall pattern. Short rains fall between October - December followed by a dry spell in January and long rains occur within February/March to mid-May. The short rains are erratic, unreliable and variable in distribution. The annual average rainfall is about 650mm. Temperatures are highest from December to February and lowest between June and July. The average maximum and minimum temperatures are 27ºC and 16ºC respectively (TANAPA, 2002). On the other hand, potential evapo-transpiration ranges from 0 - 4 mm per day. In recent years, rainfall variability has increased. It has been characterized by late onsets, short seasonal duration, early recession, and decrease in number of rain days, unpredictable seasons and decrease of rainfall amount (IDBWB, 2013).

3.3.3 Hydrological Characteristics

Tarangire River is a life supporting water source for wildlife especially during the dry season and act as a potential refugee site. This river roughly traverses the park from South to North bisecting it into two halves and drains into Lake Burunge and Manyara. During the dry season, animals concentrate along that River and associated wetlands such as Silale and water pools due to water availability. During the long dry season, the park is sustained by base flows and water retained in the swamps and few artificial water ponds/pools while wet season it is characterized with high flow and runoff.

3.3.4 Study Sites Population

The study sites population projected by Babati District Population revealed a total of 16,951 people, comprising 8,536 males and 8,414 females and total number of households stood at 3,259 (Babati District Population Projection, 2017). However, according to the Babati district population projection data of 2017, the study site population had significantly increased from 15,411 in 2014 to 16,951 in 2017 (Table 3.1) Such population increase was attributed by various driving factors such as farming, tourism, Minjingu mines and fertilizers industry and fishing. The immigrants are from different places within Manyara and Arusha regions especially nearby towns. The increasing human population raises the demand for basic resources such as food and shelter, which in turn destruct the natural environment thereby impacting the climate change on communitiesô livelihood.

Table 3.1: Population Size in the Study Sites

S/N	Village name	Population projection 2017			Total households
		Total	**Male**	**Female**	
1	Olasiti	4,783	2,376	2,407	920
2	Kakoi	4,374	2,173	2,201	841
3	Vilima vitatu	4,162	2,067	2,094	800
4	Sangaiwe	3,362	1,920	1,712	698
Total		**16,951**	**8,536**	**8,414**	**3,259**

Source: Babati District Council, 2017

3.3.5 Ethnicity and Socio-Economic Activities of Adjacent Communities

The villages surrounding TNP are inhabited by people of different ethnic groups mainly Maasai and Mbugwe (Hassan, 2007). Other ethnic groups are Rangi and Iraqw. The primary socio-economic activities are mixed farming (crops and

livestock rearing). Others include small businesses such as shops, maize mills, food vending, petty trade, tourism, carpentry and transportation. Small scale subsistence farming is performed for both cash and food crops. The main crops grown in the study area include maize, soya beans, millets and sunflower. Livestock keeping is also practiced in the study area under free range grazing. The type of livestock raised includes cattle, goats, donkeys and sheep. Moreover, due to the existence of lakes Burunge and Manyara in the nearby study area, artisanal fishermen from nearby and far town such as Babati immigrated to the area and established temporary fishing village (Goldman, 2003). Apart from that, there is also a government-partnership factory (Minjingu mines and fertilizers) located nearby study area along Arusha-Babati highway. This industry provides both permanent and temporary employment for people within study sites.

3.4 Target Population

The targeted population during questionnaire survey and focus group discussion were local communities residing in the selected villages adjacent to TNP of 18 years and above, large scale farmers, extension officers at ward and district level, environmental officers, ward and village leaders.

3.5 Sample Size and Sampling Procedures

3.5.1 Sampling of Study Villages

Babati district council has a total of 14 villages bordering TNP, which formed the village sampling frame (Table 3.2) The study covered four selected villages of the Babati District Council bordering TNP. Purposive sampling technique was used in the selecting the villages for the study. In total four villages were selected for the

study. The selection of the study villages was achieved based on its sensitivity and important contribution to the research interests such looseness to park boundary, accessibility, social services and economic activities that characterize the biophysical environment.

3.5.2 Sampling of Households to be Interviewed

As recommended, the size of sample should neither be excessively large nor too small but optimum (Kothari, 2004). A sample size of 5% was considered to be a good sample since Boyd, (1998) suggested that, for a sample to be reliable and enough to contain elements of representativeness it should be at least 5% to 10%. A household list in the study villages were obtained from the village register and study used a sample of 5% of the total households representing 162 respondents from four villages selected for household interviews.

Table 3.2: Sample Size of Household Interview

Name of Village	Number of households	Sample of households
Olasiti	920	46
Kakoi	841	42
Vilima Vitatu	800	40
Sangaiwe	698	34
Total	**3,259**	**162**

Source: field data 2018

The study employed simple random sampling without replacement in selecting households for interviews. Sampling intensities for each village of study were 46, 42, 40 and 34 households in Olasiti, Kakoi, Vilima Vitatu and Sangaiwe villages respectively (Table 3.2). Sampling units of household were selected purposely to incorporate ideas of the community members who participated in economic activities

such as farming and currently affected by climate change scenarios to incorporate their views towards climate change viz livelihood.

3.5.3 Sampling of Key Informants

The study employed purposive sampling to select key informants for interview. The sampling frame involved key respondents and target groups from local government at district, ward and village level. At district level, the agricultural extension officer, livestock officers, environmental officer and forest officer were selected for interview. At ward level, agricultural extension officers, ward executive officers and livestock officers were selected. At the village level, included representatives from village government particularly chairperson and village executive officer, elderly people who understand the area, crops buyers, livestock buyers, religious leaders and successful farmers and livestock keepers. The number of interviewed key informants is as indicated in Table 3.3.

Table 3.3: Sample Size for Key Informant Interview

Level	Categories of respondents	Number of participants
District	District Agricultural Extension Officer	1
	District Environmental Officer	1
	District Livestock Officer	1
	District Forest Officer	1
Ward	Ward Executive Officer	1
	Ward Agriculture Extension Officers	1
	Ward Livestock Officers	1
Village	Village Chair persons	2
	Village Executive Officers	2
	Elders	4
	Religious leaders	2
	Livestock buyers	4
	Crops buyers	4
	Farmers and Livestock keepers	4
Total		**29**

Source: Filed Data, 2018

Key informants were selected based on their knowledge, unique characteristics and status and socio-economic standing in the community. Interview were held with purposively selected key respondents in the community and with government officials who held different positions from the district to the village level in order to capture the most reliable information, given the limited time for the study. Interview was aimed to collect additional information from the respondents which would be difficult to capture through the use of other techniques such as questionnaire survey.

3.5.4 Sampling for Focus Group Discussion

Focus Group Discussion (FGDs) was conducted in each village to capture various background information on the livelihoods of the community in the study area and the initiatives done by the community in addressing issues related to climate change particularly challenges facing rural farmers and the way they are contributing the impact of climate change. The discussion further used to probe issues of the dynamic particularly rainfall and temperature and trends of agricultural production over time. The discussion involved different FGDs groups based on age, gander as well as socio-economic status. Purposive sampling technique was used in selecting individual from the group. The number of participants was 8 representatives in each discussion group.

3.6 Data Collection Method

3.6.1 Primary Data

The study used both quantitative and qualitative methods in collection of primary data from the study area**.** The information collected was considered as potential sources to this survey. The primary data were acquired through key informant

interviews, Focus Group Discussion, household questionnaires survey and field observation. Quantitative data were collected through a household survey using closed and a structured questionnaire. Key informant interview, field observation and FGDs provided a room for discussion that allowed for the collection of both quantitative and qualitative data. Consultations were also conducted with individuals at village, ward and district levels in Babati to supplement the data collected in the field.

3.6.1.1 Questionnaire Survey

Before commencing the study, the village chairmen were consulted and informed about the purpose of the research. Then they were asked their permission to conduct the survey in their respective villages. Prior to questionnaire survey, reconnaissance survey was carried out with the aim of acquainting the researcher with the study area. Questionnaires were pre-tested in one village after which they were adjusted to ease interpretation by data collectors and make the questions friendly to community as well as to identify ambiguities, weaknesses and omission before finalizing the tool. After completion of all the arrangement and logistic, the questionnaire survey was then administered to the individual heads of the household in the study area. Both closed and structured questionnaires were designed and used to collect information related to basic characteristics of householdôs, socio-economic, awareness and local perceptions on climate change and agricultural productivity trends.

Furthermore, the researcher was interested to know farming production system, challenges related to climate change impacts on farming production and adaptation

strategies taken by the community in overcoming the impact of climate change in their local environment. Heads of households were interviewed and depending on who was available during the interview; a husband, wife or any household member above 18 years who is knowledgeable was interviewed on behalf of the household. Identification of the household was as per 2012 Population and Housing Census (PHC) for United Republic of Tanzania define households as a person or group of persons who reside in the same homestead or compound but not necessarily in the same dwelling unit, have the same cooking arrangements, and more answerable to the same household head.

3.6.1.2 Key Informants Interview

In this study, key informants were considered as individuals who possess knowledge, status and who were able to share that knowledge and skills with the researcher (Goetz and Lecompte, 1984). Face-to-face interview with key informants were guided by semi-structured questionnaire that was administered in different key respondents or targeted group. Interviews were conducted with key respondents and target groups including the local government officials at district level, village government, village /ward extension workers, crops, livestock buyers, religious leaders, successful farmers and livestock keepers and elder peoples (male and female) who understand the area.

This method helped to obtain information which would be difficult to capture through the use of other techniques such as questionnaire survey. Interviews focused on addressing issues related to climate change particularly challenges facing farming sector, the way forward to address the challenges, sources of climate change

information and the government initiatives to overcome the impacts of climate change.

3.6.1.3 Focus Group Discussion

Four group discussions were conducted in each selected village. Different groups were involved based on gender, age as well as socio-economic status making a total of 8 representatives in each group discussion. Discussions were done upon consulting village government to make prior arrangement for the interview meeting. Participants in the discussion groups included small scale farmers, traders and herdsmen. Researcher facilitated 1-2 hours PRA meeting in each village to validate information collected during household survey and key informantsô interview.

The discussions were based on the issues and concept related to climate change challenges, social economic characteristic of local people, seasonal calendar, local perception, community contribution to climate change and the strategies used by the community to overcome the impact of climate change. A checklist of guided questions was prepared and discussed during the focus group discussion. Probing questions were used by the researcher so as to obtain more information on trends on agricultural production, challenges as well as opportunities. The data were recorded in summary form in a note book by the researcher.

3.6.1.4 Field Observations

Field observation was conducted in the study area to validate information obtained during questionnaire survey, key informant interview and focus group discussion. It involved a direct observation of the social phenomena in their natural settings

(Babbie, 1992). It was deeply conducted and enabled the researcher to obtain some facts related to this study to supplement the information obtained using other methods. The method further assisted the researcher in collecting the biophysical information. This method allowed physical observation of land use changes, settlement, deforestation, grazing and farming characteristics. Photographs and notes were also taken as evidence of what has been discussed as a means of information validation

3.6.2 Secondary Data

In this study secondary data was collected through extensive review of the literature from previous studies, both published and unpublished materials (reports, manuscripts and workshop). The review was done in libraries, internet and previous report obtained from the government offices including District, ward and villages. Other data and information related to climate change such as rainfall and temperature trend and variability over 40 years were gathered from the local weather stations located within TNP and adjacent area such as Magugu weather station which is supervised by Internal Drainage Basin Water Board (IDBWB).

3.7 Data Analysis

Data were collected from primary and secondary sources and entered in Ms-Excel 2007. Quantitative data from respondents' perceptions and questionnaires responses were compiled and analyzed by using IBM Statistical Package for Social Science (SPSS) version 20 where descriptive statistics such as means, frequencies and percentages were applied and results presented in tables, bar and pie charts. Rainfall and temperature data were compiled, analyzed and results presented in graphs to

show trends and variability over years. The qualitative data from key informant interviews, focus group discussions and observations were subjected to content analysis and presented in a summary form using cross- tabulation (Ashley, 2006).

3.8 Validity and Reliability of Research Instruments

Validity determines whether the research truly measures what it was intended to measure and how truthful the research results are (Golafshani, 2003). This study has mainly focused within intended objectives by choosing appropriate survey method and assessed the situation on ground to validate information obtained during interviews. It was also considered by ensuring methodology used to collect the secondary data in the study conform to approved standards such as weather monitoring equipment and also relied on supervisor and other expert advices. Reliability ensures data consistency over time and an accurate representation of the total population during sampling. This study has applied triangulation method such as questionnaire, interviews, key informants and focus group discussions in investigating a single context that provided diverse construction of realities and was also gauged to previous similar studies.

3.9 Ethical Considerations

Clearance letter of introduction from the Open University of Tanzania was obtained and submitted to involved administrative offices of the study areas including Babati District Council to seek permission and introductory letter to Village governments. Additionally, it was also submitted to TNP authorities to get permission to use available secondary data for this study. Consultation with respective local government authorities was also taken into consideration for questionnaires survey

and focus group discussion. Prior to data collection, the respondent`s blessing was sought. This involved providing the respondents with general information of the study and opportunity to demand more clarification before interview. The privacy of the participants involved in interview was well thought-out to the maximum with respect to the laws

3.10 Justification

Climate change impacts is already being felt almost globally in terms of gradual increase in temperature, erratic and annual rainfall variability and a greater prevalence of extreme events such as drought and floods. However, climate change has become a major threat to rural livelihoods and to crops and livestock production in the developing countries. The rapid population growth and new settlement towards TNP boundary as well as encroachment of potential wildlife habitats has fueled climatic variability within TME. Majority of adjacent communities' economic activities have direct links to climate change. The climatic variability in areas within TME have been clearly observed and confirmed over the past decade. These events have been inducing frequent drought and flush floods all of which imposes enormous effects to TNP and beyond park boundaries to adjacent communities.

However, the extent to which the surrounding communities are impacted is not well known and documented. This study therefore assessed and analyzed the past and existing situation linking agricultural productivity trends of adjacent communities to earmark significant impact related to climate change. Furthermore, it examined climate change perceptions of the local communities around TNP and recommend possible mitigation measures and adaptation strategies

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presented the results of the study to meet three specific objectives based on the questionnaires administered. Demographic characteristics of the study population in terms of age, sex, education level, marital status have been clearly discussed. It also analyzes the results of climate change in the area, community knowledge and experiences on climate change, awareness of climate change, impacts on vulnerabilities and livelihoods, biodiversity and adaptation strategies

4.2 Socio-Demographic Characteristics of the Respondents

The important demographic characteristics of respondents that were involved in this study were age, sex, education level, marital status, origin and the duration of stay of the respondents in their localities. However, during data collection a total of 162 questionnaires were administered to the respondents and they were all filled in as required.

4.2.1 Gender of Respondents

Table 4.1: Gender of Respondents

Gender	Respondents	Percentage
Male	109	68
Female	53	32
Total	**162**	**100**

Source: Research Data, 2018

A total number of 162 respondents were provided with the same number of structured questionnaires and all responded on the question of gender. As presented

in Table 4.1, about 68 % of the respondents were males and 32 % were females. A high number of males were involved in questionnaires survey because most of them are head of the family that made them easily targeted during survey.

Despite of the gender bias happened during questionnaires survey, the study ensured equal representation during FGDs and key informants survey to get views and contribution of women. It is important to combine both views since males and women played different significant role within communities. They also have different understanding, experience, priorities and ability to deal with the impacts of climate change. According to UNDP, 2012 report on climate change impacts, both genders plays different roles based on different responsibility at the household and community level. However, women are more exposed to effect of climate change because they are often poor, receive less education and not involved in political and household decision making that affect their lives.

4.2.2 Age of Respondents

Table 4.2: Age of Respondents

Age group (years)	Frequency	Percentage
36-45	53	33
46-60	48	30
18-35	36	22
60+	25	15
Total	**162**	**100**

Source: Research data, 2018

Age plays important role as it also enable to get the right answer from the respondents. As is revealed in Table 4.2 below, a total of 162 respondents were involved in survey with age distribution range between 18 and over 60 years. About

33 % of the respondents were between the ages of 36 - 45 years whilst 45 % were aged 46 to 60 years and above. Majorities of the interviewed respondents fall within the age group ranging 18-60 years which implied that they are the workforce group capable of utilizing the available resources and contribute to climate change scenarios. Age group above 60 years is knowledgeable and able to identify past changes due to human development and population growth over years with increasing demand for resources within study area.

4.2.3 Education Level of the Respondents

The results indicated that, out of the 162 respondents 46% of the respondents had attained primary school education level whilst 32% had never attended any formal school and only 22% attained secondary school education and above as presented in Figure 4.1.

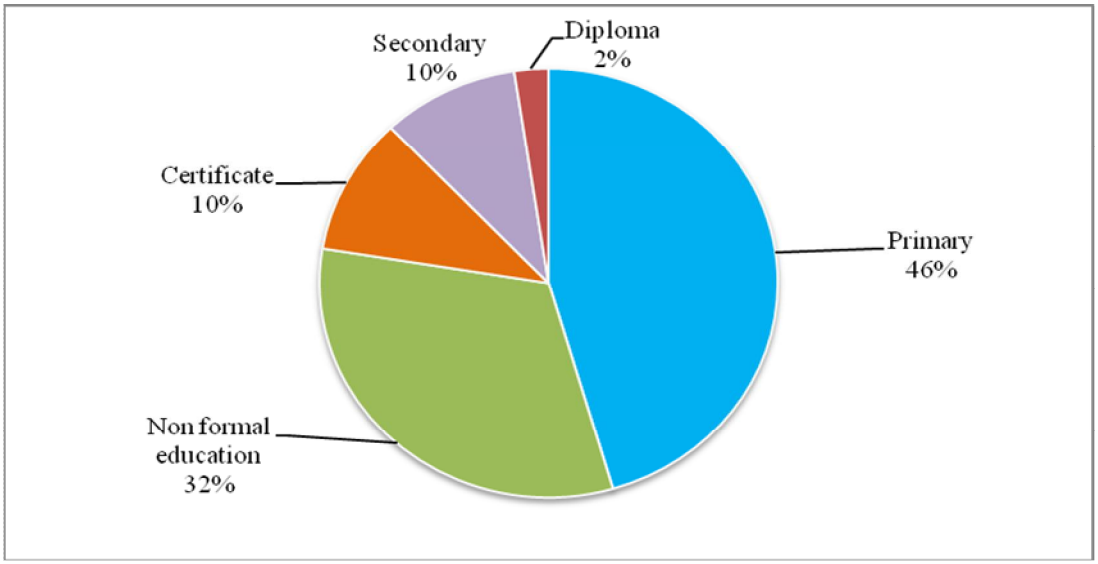

Figure 4.1: Education Level of the Respondents
Source: Research Data 2018

Based on the study result, it was revealed that about 68 % of the respondents had access to basic education and therefore they were able to associate ongoing daily

activities and changes happening in terms of climate and it impact their livelihood. Respondents who had never attended any formal school accounted 32 % but had lived longer in the area and involved in many economic activities and can explain on physical changes they observed in relation to climate change aspect viz community livelihoods

4.2.4 Marital Status of the Respondents

The study results revealed that out of 162 respondents, 91 % were married, 1% widowed, 3% divorced and 5 % were single as presented in Table 4.3. Thus, being the majority of the respondents are married and are both holding family responsibility make them aware of the prevailing situation impacting community livelihood and jointly engaged in climate change adaptation activities to safeguard their families.

Table 4.3: Marital Status of the Respondents

Marital status	Respondents	Percentage
Married	148	91
Single	8	5
Divorced	5	3
Widow	1	1
Total	**162**	**100**

Source: Research Data, 2018

4.2.5 Respondents Origin and Duration of Stay in the Study Area

The study results revealed that, out of 162 respondents, 99 % were resident of the area whilst 1% migrated to the area as presented in Table 4.4. The essence of majority being dwellers provides opportunity of getting proper information and impacts evidence with regards to community livelihoods and climate change impacts on economic activities.

Table 4.4: Respondents Duration of Stay in the Study Area

Duration of stay	**Respondents**	**Percentage**
Less than 10yrs	2	1
10 years +	160	99
Total	**162**	**100**

Source: Research Data, 2018

4.3 Climate Change Perceptions

This section presents the ranking results on local communityôs perception and understanding of climate change and its associated impacts. With regard to adjacent community perceptions and knowledge on climate change during household interview, out of 162 respondents, 65% perceive it as drought and decrease in amount of rainfall whilst the remaining perceived it as global warming (14%), destruction of forest (11%) and scarcity of water (9%). However, few respondents (1 %) were unaware of the climate change scenarios as presented in Table 4.5.

Table 4. 5: Local Community's Climate Change Perceptions and Knowledge

Perception and Knowledge	**Responses**	
	Frequency	**Percentage**
Drought	106	40
Shortage of rainfall	67	25
Global warming	36	14
Forest destruction	29	11
Water scarcity	24	9
I donôt know	3	1
Total	**265**	**100**

Source: Research data, 2018

With regard to perceptions and knowledge results, majority of the respondents seemed to be aware of the climate change aspect contributed by level of education, age and other interactions in their daily economic activities. The age group of above 60 years had indigenous knowledge and therefore was able to clearly explain the changes which occurred in their localities including specifying exactly the time of

the changes. For example, during FGD one of the participants said;

> *.... in the past years, there was a lot of natural spring which used to flow all the year around but today most of them have disappeared due to changes in climate.*

Based on FGDs results, the majority were unaware if climate change still happening due to the fact that the changes are detected over a long period of time. During FGDs it was reported that drought incidences had occurred in some years back but its occurrence was very rare and if it occur it took an interval of time to the extent that people would be able to detect its next occurrence. However, interview conducted with key informants especially, ward agricultural and extension officers revealed that, recently drought incidences in the study area had occurred very frequently and almost every season of the year which in turn had resulted in crop failures and therefore affected the livelihoods of local communities at household level.

In general, the study results, FGD and key informants interview established that, the persistence of drought conditions and changes in weather parameters particularly rainfall and temperature had resulted in low crop production, which in turn had made some farmers to abandon cultivating some crop varieties. An interview conducted with key informants established that the area under study had not received enough rainfall for a long period of time to support their activities especially farming and livestock keeping. One of the participants was quoted saying:

> *.....nowadays rainfall has become erratic, low and highly variable from one season to another. This is quite different from the previous years whereby we received enough and predictable rainfall.*

Generally, 99% of the respondents interviewed in the selected villages in the study area demonstrated reasonable level of understanding and awareness about the concept of climate change and the likely causes with evidences within their local environment. Although most of the dwellers do not understand the science behind climate change, but their direct observation on the effects of rainfall decrease, increasing sunshine intensity, air temperature and seasonal variability in rainfall patterns is very remarkable.

Unfortunately, there is a general lack of public awareness or worse, complete misunderstanding which undermines the public willingness to participate or support government adaptation efforts (Lorenzoni *et al*. 2007; Jude, 2008). Despite the well-known scientific conclusion, that worldwide climate change is happening, generally human induced and serious risks, public understanding of these facts and support for climate change policies is more ambiguous worldwide (Leiserowitz, 2007; Brechin and Bhandari, 2011).

Levels of climate change awareness, knowledge, perceived risks and support of mitigation or adaptation vary greatly across the world (Bord *et al*. 1998). According to MingLee *et al*. (2015), climate change awareness and risk perception were unevenly distributed around the world in 2007 - 2008. The highest level of awareness (over 90 %) were reported in developed world whilst majority in developing countries had never heard of climate change including more than 65 % of respondents in countries such as Egypt, Bangladesh, Nigeria and India. Generally, national, cultural and geographic factors play an important role in shaping individual level perceptions of climate change.

4.3.1 Perceptions on the Causes of Climate Change

The respondent's knowledge and awareness on climate change were also assessed during the study and the majority associated it with deforestation (33.4 %), agricultural activities (16.1 %), industrial activities (11.6 %), overstocking while others responded as Gods plan (11.3 %) as presented in Table 4.6. Other responses such as the use of charcoal (6.9 %) and fossil fuel were purposely interviewed to get the clear picture if the majority are aware of the link and scientific concepts about climate change scenario and it was revealed that they are aware about the general concept rather than scientific conclusion which might hinder mitigation and adaption activities without prior awareness campaigns. Generally, the level of knowledge and awareness varied between age group with more aged linking it with Gods plan compared to others.

Table 4.6: Climate change contributing Factors

Factors	Responses	
	Frequency	Percentage
Deforestation	120	33
Agricultural activities	61	16.8
Industrial activities	42	11.5
Godôs plan	41	11.3
Overstocking	36	9.9
Use of biomass (firewood and charcoal)	25	6.9
Increased greenhouse gases in the atmosphere	14	3.8
Use of fossils fuels	13	3.6
I donôt know	12	3.3

Source: Research Data, 2018

According to respondentôs opinion, deforestation was ranked highest contributor to climate change within community adjacent to the park probably because they had opportunity to compare between their environment and adjacent protected areas with regards to climate change impacts happening within the two areas. The study results

indicated that deforestation was attributed by the increase in population and demands for natural resources. Field visit observed local people cutting down trees not only for farming activities but also for charcoal burning which stand as a source of income and alternative energy (Figure 4.2).

Figure 2.2: Pictures showing Pile Logs which are Used to Make Charcoal as a Major Source of fuel in the Study Area

Source: Field Observation 2018

Based on FGDs and key informant interview, it was reported that, most local people in the study area depends on forest resources as their means of income and energy. The recent decades have seen a dramatic increase in tropical deforestation caused by conversion for the establishment of more permanent agriculture, plantations and pastures, which often results to degraded grasslands or degraded fallows (Tinker, 1996). Large scale conversion of the tropical forest could lead to changes in climate. According to Model simulation run by Nobre *et al.* (1991) for Amazonian forest, it was clearly reveled that, if the Amazonian forest is converted to pasture, there will be a significant increase in the mean surface temperature (about 2.5^{o}C), and a decrease in annual evaporation (30 % reduction), precipitations (25% reduction) and runoff (20 % reduction) in the basin.

Agricultural activities encompassing farming and livestock keeping were also ranked the second higher contributor (26.7 %) to climate change impacts within the study area. The area was dominated by Maasai who are livestock keepers and other tribes practicing small scale agriculture which involves clearing of the indigenous forest to get farmlands. Based from FGDs and key informant interviews, it was reported that climate change is mainly caused by shifting agricultural activities. One key informant was quoted saying that;

> é .*Farmers tend to extend their farms by clearing the virgin forest with the aim of increasing productivity instead of using modern farming practices.*

According to HLPE (2012) agricultural activities contribute by emissions of greenhouse gases and conversion of forest to farm land. However, traditional trends of keeping a large number of cattle and other livestock were clearly observed with impacts on soil structure and fostering erosion with significant impacts to water resources. Within the last decades, water quantity and quality have become increasingly, a serious issue for water resources management at catchment or regional scale due to human activities (IPCC, 2007). According to Gerber *et al* (2013), overstocking contributed 14.5% of global GHG emission and thus may increase land degradation through trampling, air and water pollution and loss / decline in biodiversity. Field observation spotted a huge number of livestock grazed under free range within the community farm (Figure 4.3).

Industrial activities were also ranked high (11.3%) due to existence of Minjingu mines and fertilizer industry in the peripheral of the study area. During FGDs and key informant interviews, it was revealed that the said industry emits fumes and dusty that destroys not only ozone layers but crate chaos to the surrounding

communities. Intergovernmental Panel on Climate Change (2007) reports revealed that, the main cause of climate change is the raising concentration of greenhouse gases (GHGs) in the atmosphere, which stem primarily from both natural and human activities. It furthers lists down the main GHGs as carbon dioxide methane, nitrous oxide principally from the burning of fossil fuel, forest destructions and agriculture and fluorocarbons, CFCs used in air conditioners and many industrial processes.

Figure 3.3: A picture showing Livestock Grazing Free Range in the Farm
Source: Field Observation 2018

4.3.2 Local Community's Perceptions on Climate Change Indicators

The awareness of the indicators is more profound due to easy detectability in the surroundings, routine social and economic activities. During interview it was clearly revealed that the majority of community members are aware of the climate change indicators as ranked in Table 4.7. With regards to climate change indicators, respondents (10.5 %) ranked increase in temperature as the highest climate change indicator within their area probably due to the impacts it produces to agricultural activities and communityôs livelihood as presented. The respondents shared their views on the increase in temperature and explained that. The sunshine intensity has

increased which ultimately resulted to the increase in temperature during the day and in the midnight.

Table 4.7: Local Communities Climate Change Indicators

Climate change indicators	Responses	
	Frequency	Percentage
Prolonged growing season	106	7.4
High Temperature	151	10.5
Shortened growing season	151	10.5
Low production	146	10.2
Rainfall shortage	142	9.9
Drought incidences	136	9.5
Unpredictable rains (Erratic)	124	8.7
Late rains	125	8.7
Diseases outbreak	94	6.6
Crops and animal pests	88	6.1
Early rains	71	5.0
Floods incidences	62	4.3
Increased rains	19	1.3
Plants species extinction	17	1.2

Source: Research Data, 2018

Shortened growing season was ranked by 10.5% of the respondents and explained that the area has been characterized by very short period of rainfall seasons. During FGD the respondent further narrated that planting seeds early is no longer reasonable due to irregular and unpredictable rainfall. Early planted crops dry due to drought and others are eaten by termites. This finding is similar to a study by Krishna (2011) and Gyampohet *al.,* (2009), which suggested that indigenous traditional weather prediction knowledge is becoming less reliable because, in some instances, these events may occur earlier than normal, and thus do not coincide with the start of the growing season which may mislead the farmers.

Low production of food crops was also reported by 10.2% of the respondents since drought condition leads to less production due to crop failure. The drought condition

did not affect only staple foods like maize and beans but also cash crops like cowpeas, sugar cane and pumpkins which are the major supplements of maize in case of drought condition. Shortage of rainfall 9.9% and drought was also ranked high as the indicator of climate change 9.5%. Increase in temperature was found to have a direct link with frequently drought condition which has caused some of the areas to be unsuitable for farming activities.

During the FGD it was reported that the increase in drought condition make it easier for the termites to feed on the dry crops which ultimately results into shortage of fodder for livestock. According to Collier *et al*. (2008), climate change induced drought condition will make some areas unsuitable for farming activities. Research results and direct observation revealed that, some crop varieties which were grown early in the season were no able to reach maturity due to prolonged dry season (Figure 4.4).

Figure 4.4: A picture showing wilting Crops due to Prolonged Dry Season at the Study Area
Source: Field Observation 2018

4.4 Climate Change Mitigation and Adaptations

According to FGDs, it was clearly stated that communities around the study areas adapt to the climate change impacts scenarios by introducing new crop varieties and changing planting dates or seasons to suit the existing weather trends. One of the participants during focus group discussion reported that with varied rainfall amount and intensity, planting early when the soil is still wet is better because it helps crops to tolerate for a certain period of time before it rains again.

Another participant reported that, traditionally first rain was just as an alert for the starting of the season and majority of the local farmers would start preparing their farm ready for planting and other would sow seed to utilize the early rains and benefit out of that. However, key informants interview revealed the nomadic state of livestock keepers when signs of persistent drought are earlier observed. They tend to move cattle and other livestock to other regions which are not affected by the change in weather. For those remaining within the study areas adopt by constructing water dams to ensure water availability to their livestock during the drought disaster.

It has been documented that mitigation and adaptation initiatives can reduce harmful impacts of climate change (Kabubo-Mariara & Karanja, 2007). These measures comprise growing of alternative crops, use of drought resistant tolerant seed varieties, intercropping different crop varieties, water harvesting techniques and irrigation initiatives, changing planting dates and agricultural diversifications. They further reported that, adaptations initiatives targeting micro-level farmers, market responses, technological advancement and institutional changes have a large

potential in reducing negative impacts of global warming and climate change.

Adaptations involve how community members perceive climate change and their associated impacts and action taken to minimize risks. Correct perceptions depend on the knowledge and information access as realized in the study area adjacent to TNP. Despite of the correct perceptions in such rural areas, dwellers do not respond to climate change associated impacts as they lack capacity, resources and information (Tripethi & Mishra, 2016). They further reported that adaptation strategies differ from sector to sector and each face specific challenges. Adaptation towards agriculture such as declining crop production with regards to climate change in developing countries is a big challenge, due to vast majority farmers are marginal and smallholder farmers less educated and have considerably lower adaptive capacity. However, even if adaptations were possible, rural farmers who mostly are smallholders could not offset losses associated with climate change (McCarthy, 2001).

4.5 Weather trends and Climate Change Information

4.5.1 Total Annual Rainfall

Analysis of rainfall trends has a paramount importance to deal with impacts on crop yields and animal production. The rainfall trend was obtained through the analysis of data recorded from TNP Ecology Department weather station over the past 40 years from 1979 to 2017. The results shows an insignificant decrease in total annual rainfall by 17% since the the slope of the regression line was R^2 =0.1798 at 95% confidence level (Figure 4.5).

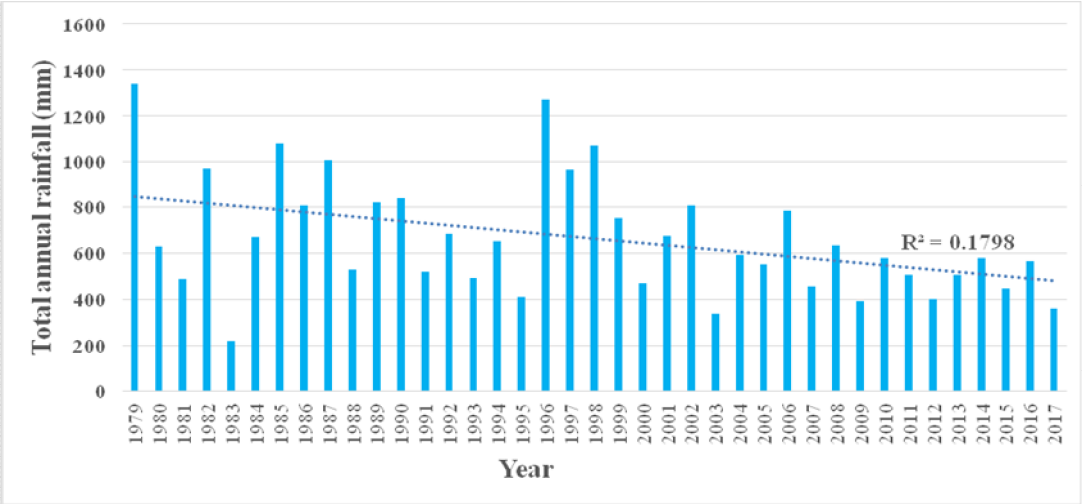

Figure 5.5: The Total Annual Rainfall Trend of TNP (mm/year) from 1979-2017

Source: TNP Ecology Department

The decrease in rainfall amount, its distribution and variability over the past 40 years was also commented by respondents during FGD and Key informant interviews as one of the climate change indicators in the study areas. The respondents further reported that, in current years from 2015 they are receiving very small amounts of rainfall as it can be supported by the Figure 4.4. Also, during FGD it was reported that sometimes they receive heavy rainfall within a short time of period which results to destruction of crops and infrastructure which is then followed by prolonged drought. This scenario confuses farmers and livestock keepers on when to plant their crops and availability of fodder.

Considering the history of recurrent drought and rainfall variability in areas adjacent to TNP and conducting long term trends and variability studies to enrich the community with information on what has been changing in the past has a vital contribution in sustaining their livelihoods. Similar comments have been reported by Riddle and Cook, (2008) that, since agricultural calendars in most parts of Africa is

closely tied to the timing of local rainfall, improved prediction of rainy season onset and termination would greatly be beneficial for smallholder farmers. Cheung *et al*. (2008) emphasized that in countries with such low-productivity rain-fed agriculture, rainfall trends and variability are usually refered in explaining socio-economic problems such as food insecuritry.

4.5.2 Average Annual Rainfall Trend and growing Seasons

The results from the analysis of average monthly rainfall showed that, the area is characterized by semi-arid climate with a prolonged dry condition with a bimodal rainfall type which can be observed separately in terms of growing season of crops. The first short rainy season extends between September to December which locally called *'vuli'* with average rainfall ranging from 2mm to 117mm. The second-long rain season extends from January to May and locally known as *'masika'* with average rainfall ranging from 51mm to 114mm and dominated by cold weather with moderate temperature (Figure 4.6).

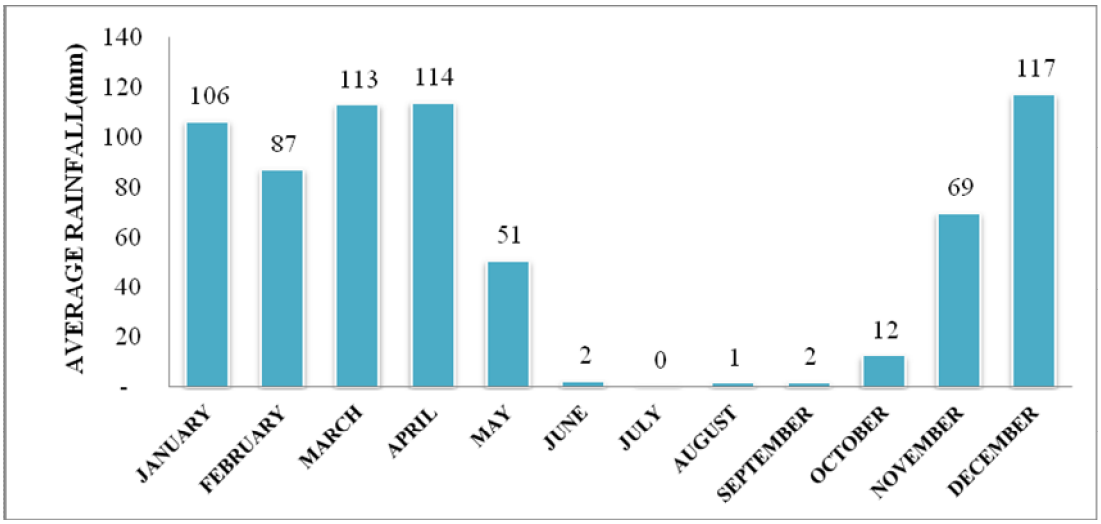

Figure 6.6: The average Monthly Rainfall Trend of TNP (mm/month) from 1979-2018

Source: TNP Ecology Department

However, the results from this study somehow do not concur with the results obtained from key informants and FGD. According to the respondents it was reported that short rains starts from October to late December. Usually in January the area does not receive rainfall until late February to May where it peaks and decline on June. The discussion with Babati district officials found that, rainfall trends as well as growing season have totally changed in a way that one season can receive sufficient amount of rainfall while other consecutive seasons can receive very little rain or sometimes one year can receive very heavy rainfall but the next followed 2 to 3 years can receive very poor rainfall at a varied interval which cannot support farming activities and livestock keeping. One participant during FGD was quoted saying that;

> *In the past years we used to plant maize, beans and cow peas in late November but currently due to variability in rainfall pattern we start planting them in either late January or early February every year.*

The interview with Babati district agricultural extension officer found that, timing and the length of growing season have changed due to the great variation in rainfall pattern and duration. She further suggested that nowadays rainfall does not follow the normal trend as in the past and this situation have affected the normal growing season which in turn had ended up with having a poor yield and thereby affecting the community livelihoods.

Generally, during FGD and key informants interviews the participants reported that nowadays the rainfall has become variable, low in volume and higher in intensity. During FGD the one respondent said;

> *...previously, during the rainy season natural ponds, rivers used to be fully filled with water and sometimes flooded. Currently, the water does not*

cover even half of the ponds or river and stay for a short time of period

The respondents further reported that, currently they are not receiving enough rainfall to support farming activities sufficiently from germination to maturity. On the other hand, some areas receive heavy or low rainfall which is concentrated within a short time of period which does not permit the growth of crops to maturity.

4.5.3 Temperature Trends

The analysis of the mean maximum and minimum temperature data collected from 1987-2017 provided vital information on the temperature trends. Using linear regression model, the rate of change was defined by the slope of the regression line. The results found significant trends for mean maximum temperature on annual basis (R^2=0.5678) at 95% confidence level. However, insignificant trend was observed in mean minimum temperatures on annual basis where R^2=0.3378 at 95% confidence level (Figure 4.7).

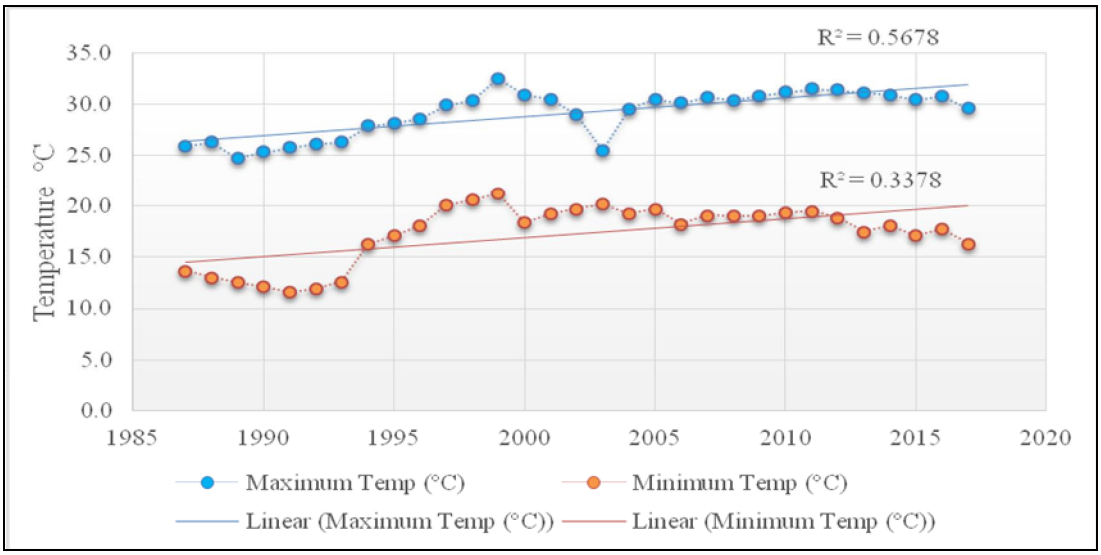

Figure 7.7: Annual Mean and Maximum Temperatures for 30 past Years from 1987-2017

Source: Internal Drainage Basin Water Board -Magugu Weather Station

These results are in line with the views of the respondents since during FGD the respondents reported that in recent years they have experienced an increase in sunshine which influences the surface temperature in their areas. Also, daily temperatures are perceived to increase which ultimately leads to increase in the evening and midnight temperatures. The existence of trends in maximum temperature supports the concern raised by respondents and focus group discussion that temperatures have been increasing over the past 30 years. Similar studies on the same increase of temperature have been reported by other scholars in different parts of Tanzania and East Africa (Kangalawe, 2012; Majule and Mary, 2009; Munishi *et al*. 2010). During FGD the respondents further explained that nowadays temperature has increased during the day time which has also triggered its increase in the evening to somehow midnight. In the discussion some participants were quoted saying that;

> *Temperature is high in both day and night time to the extent that it has made people to sleep without having a bed sheets and leaving their window open to midnight.*

Research findings by Kabubo-Mariara and Karanja (2007) states that, temperature as an indicator of warming globally is much important aspect to look at. Generally, the past three decades have been the warmest in history with each period being warmer than the preceding one (IPCC, 2014). Such rapid and unpredictable changes in temperature deepen the vulnerability of crop production systems and directly impacting communities' livelihoods.

Osman-Elasha (2008) has reported that, African continent currently is warmer than it was 100 years ago. Future climate change impacts are projected to worsen as the temperature continues to rise and precipitation becomes more unreliable. At a broad

scale, the negative impacts of increasing temperature in crop yields is quite clear (Lobell and Field, 2007). The rising temperature would expose millions of people to drought and food shortage. Such unpredictable changes in climate will impose a serious threat to agricultural production and local livelihoods worldwide. Reversing such threats requires farmers to adapt through farming systems alteration and land management decisions that will reduce the negative consequences linked with climate change (Jarvis *et al*. 2011).

4.6 Weather and Climate Change Information Source

The study results showed that the majority of the respondents get weather information through radio (46.2 %) due to accessibility of radio in every household. Other sources include television (26 %), Newspaper (18.1 %) and less through internet (1.7 %) as presented in Table 4.8.

Table 4.8: Media through which Weather Information is Broadcasted

Weather information	Responses	
	Frequency	Percentage
Radio	133	46.2
Television	75	26
Newspapers	52	18.1
Social media	21	7.3
Internet	5	1.7
Studies	2	0.7

Source: Research Data, 2018

Effective communication on climate and weather help to inform public and policy makers about potential impacts and steps that can be taken to reduce risks. The communication needs to be targeted to specific groups, considering varying level of understanding, cultural and ethnic differences (Maasai tribe), vulnerability to climate change impacts and other factors. As such consistent climate information provides

farmers with predictive information about environmental risks that helps them conquer prior knowledge about environmental risks that helps them overcome prior knowledge constraints (Rosenzweig and Udry, 2013).

4.6.1 Weather Forecast Information

The study results found that, the majority of the respondents in the study area uses their own observation (59%) to detect changes in climate though looking at the variability in weather factors and its associated implications particularly prolonged drought condition, rainfall (later or early rainfall) dry spell, temperature trend and rate of productivity. Based on the FGDs and key informantsô with Babati district farmer and extension officer, it was established that apart from fellow farmers (16%) and mass media (13%), respondents also receive climate change information through public meeting at village level (Figure 4.8).

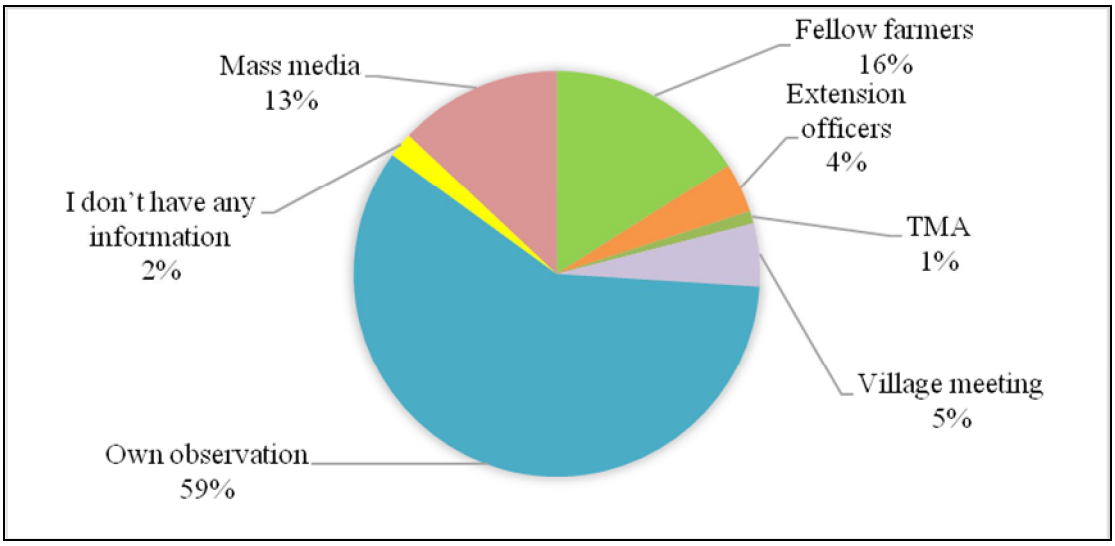

Figure 8.8: Sources of Climate Change Information
Source: Research Data, 2018

A farmer in Nkaiti ward was quoted saying that:

é *The individual knowledge and experience on climate change have*

> *been used as a source of information for a long time but nowadays there is accessibility of mass media information especially from radio which every household have access to it*.é

According to Kates *et al.* (1985), information for many climatic changes with associated risks can be obtained from indirect sources. Based on the results from the study area, it is clearly observed that the majority do not get such information from government sectors within their area but rather from other sources indicating less accountability of the responsible government sectors. Weather variability has been shown to extensively impact crop yields (Lobell *et al*. 2011b), yet it may be complicated to farmers to properly adapt to such risks on their own given difficult for individual farmer to forecast weather patterns that may results to loss of crop yields. Such information will support smallholder farmers to decide which agriculture technologies and adaptation strategies that may be most useful in responding to weather variability and climate change (Ziervogel and Ericksen, 2010).

4.7 Agricultural Productivity

4.7.1 Crops Production Background

Nearly 80 % of Tanzanians are subsistence farmers who rely on the weather for their livelihoods and lives in rural areas. According to UNHCR (2009), changes in weather condition potentially affect agricultural activities (both farming and livestock keeping) through changes in rainfall (timing and intensity), temperature and other associated implication in the environment. The study area which is within Manyara Region is inhabited by agro-pastoralist in the sense that they practice both small-scale farming and free-range livestock keeping. Among the potential crops

grown in the area includes cereal crops and sunflowers in small scale to meet demand for foods and small portion for commercial purposes. Livestock keeping in the area is extensively practiced by Maasai tribe and includes cattle, goats and sheep.

The study conducted by Nonga *et al*., (2011) within the same district revealed that, the highest number (95 %) of households grew crops namely maize, beans, rice, banana and vegetables with a median farm size of 3 ha. This study analyzed crops and livestock types existing in community adjacent to TNP, farm sizes, ownership and production trends over the past few years. The research noted that maize (41.4 %) is the highest crop preferred by dwellers within the area followed by beans (14.2 %), sunflower (14.2 %) and rice by 13 %. Fruit and vegetable are least cultivated to supplement other sources of food in the area as presented in Figure 4.6. Based from FGDs and key informants interview, it was also revealed that maize is the main food crop cultivated and some portion of it sold to earn household income to support other activities.

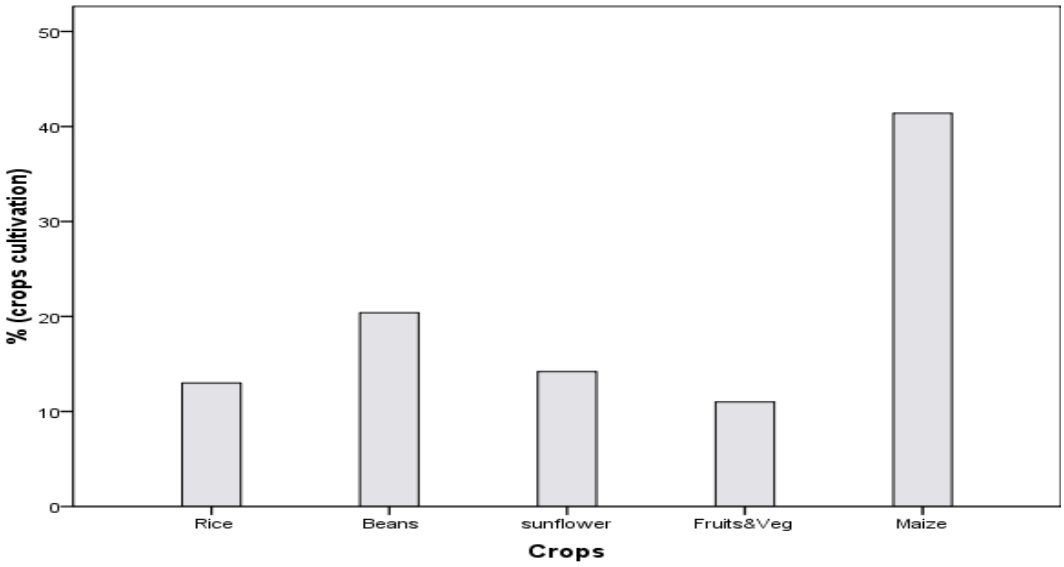

Figure 9.9: Crops cultivated in the Study Area
Source: Research Data, 2018

However, maize is mainly important staple crop for food security and livelihood of small holder farmers in many parts of Sub-Saharan Africa, but stand alone cannot ensure food security (Rajedran *et al*. 2017). Cropping patterns must be diversified similar to what observed in the study area to ensure an adequate supply and economic access to greater variety of foods for small holder farms households.

4.7.2 New Crops Varieties

On the other hand, Climate change and variability, unreliable crop market as well as business factors were identified to be the main reasons of small holder farmers shifting to other crop varieties. According to research results, the most preferred new crop was sesame (29.1%) while the lowest was water melon (1.2 %) normally cropped during the dry season under irrigation scheme systems. Other crops include sunflower (27.9 %), cowpeas (22.4%), Sorghum (12.1%) and parenting (7.3 %) as presented in Table 4.9.

Table 4.9: New Crop Varieties

New crops varieties	Frequency	Percentage
Sesame	46	29.1
Sunflower	46	27.9
Cowpeas	37	22.4
Sorghum	20	12.1
Parenting	12	7.3
Watermelon	2	1.2
TOTAL	**165**	**100**

Source: Research Data, 2018

According to FGD, the majorities have changed crop varieties due to economic, social and environmental factors but farmers also respond to political factors than weather and climate during opting in crop varieties changes. The rural level smallholder farmers similar to the area are severely influenced by climate change as

they have the low adaptive capacity to its impacts such as low crop productivity. In other countries, scholars point out that adverse impact of climate change on agricultural production can be minimized through crop diversification (Esham and Garforth, 2013). Additionally, Bryan et al. (2013) noted that, agricultural measures such as the use of improved new crop varieties are widely used adaptation strategy to climate change scenarios.

4.7.3 Abandoned Crop Varieties

Crops varieties abandoned by majority include beans (36.4 %) than any other food crops that were previously cultivated by communities' adjacent TNP. Other crops which were abandoned equally including cowpeas by 18.2 %, smart beans by 18.2 % and parenting by 18.2% while sunflower was least abandoned by most of the respondents by 9.1 % due to its economic potential as shown in Table 4.10. The findings further highlighted the main reason for abandonment is economic reason that is lack of market by 78 % of the respondents, rainfall scarcity and drought accounting a total of 22 % of all the respondents who participated in interview session.

Table 4.10: Abandoned Crops in Recent Years

Abandoned crops varieties	Frequency	Percentage
Beans	12	36.4
Smart beans	6	18.2
Cowpeas	6	18.2
Parenting	6	18.2
Sunflower	3	9.1
Total	**33**	**100**

Source: Research Data, 2018

However, it was clearly discussed during FGDs and key informantsô interview that, some of the small-scale farmers have abandoned cultivation of some crop varieties

due to prolonged droughts and shortage of rainfall. Additionally, extension services recommended introduction of drought resistant crop varieties that convinced smallholder farmers to shift to other crop productions. According to Menike and Keeragala Arachchi (2016), the majority of the farmers opt to take adaptation strategies to cope up with climate change where the leading method is to shift to short season crops (87 %), drought resistant crops (7 %) and least through adjusting planting dates (3 %) and tree planting (3 %). However, they clearly observed that, smallholder farmers have a high responsiveness of changes in weather and always have taken appropriate measures to cope with the impacts of a changing climate.

4.8 Crop Production Trends

4.8.1 Trends in Maize Production

Maize production amounts for about 75 % of the total cereal consumption making it one of the strategic crops for food security in Tanzania (Msuya, 2009). It is widely cultivated in the country due to favorable climatic conditions. The study results revealed that, most of the respondents in the study area have placed much of the efforts on maize cultivation and beans as their main preferred staple food..

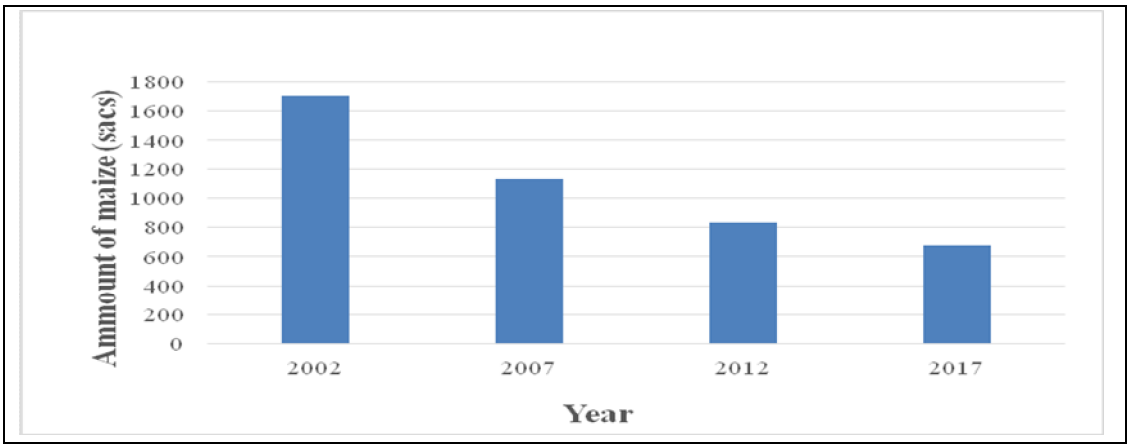

Figure 10.10:Trends of Maize Production
Source: Research Data, 2018

The trend of maize production has been declining yearly (Figure 4.7) regardless of increasing rate of maize cultivation. The result shows that, the number of people engaging in maize cultivation has increased in the past five years. The results showed in the recent year of 2017 accounting 55.7 % while the past five years in 2012 having only 5.7 % indicating increase in small scale farmers cultivating maize as presented in Figure 4.7

According to Porter *et al*. (2014), in the past 30 years climate change has contributed to global agricultural production declining by 1-5 % per decade which is expected more severe to some localized area based on vulnerability level. The available data within the same region revealed that, the average crop yield per hectare has declined from 14071.24 kgs in 2007/08 to 1122.54 kgs in 2009/10 production seasons (FAO, 2011). Based on FGDs and key informant interview, it was pointed out that production was significantly stable in previous years to sustain food supply but currently they need to import maize from other areas to meet food demand annually. Similarly, agricultural trade has grown significantly and currently provides considerable food supplies and substantial income to importers and exporters respectively. Such examples emphasizes the relationship between climate change and agriculture, trends of food trade and security and the need to integrates climate change impacts in a global context (Parry *et al*. 1999)

4.8.2 Factors Limiting Maize Production

Climate change is expected to badly hinder crop production in Sub-Saharan Africa where it forms the backbone of most countriesô economies (Abdul-Razak and Kruise, 2017). The study results found maize production decline contributed by

persistent drought (33.1 %), while 30.6 % responded excess and average rainfall, rainfall shortage (19.4%) and the least were elephant, pest and soil fertility as shown in Table 4.11.

Table 4.11: Factors limiting Maize Production

Limiting factors	**Responses**	
	Frequency	**Percentage**
Drought	41	33.1
Rainfall shortage	24	19.4
Excess rain	20	16.1
Average rainfall	18	14.5
Pests outbreak	10	8.1
Soil fertility	7	5.6
Elephants raiding	4	3.2
Total	**124**	**100**

Source: Research Data, 2018

Interview with Key informants and FGDs participants established that, the underline reasons for the fluctuating and decline in crop production may be attributed by prolonged drought condition, use of inappropriate seeds (repeated seeds), insufficient amount of rainfall and distribution, problem animals (especially elephants), decline in soil fertility, crops pest and pest diseases outbreak and poor farming practices. The rapid and uncertain change in temperature and rainfall pattern deepens the vulnerability of the agricultural systems, especially today's realized impacts on food production. Porter et al., (2014) pointed out that, such trends is anticipated to build up in the near future with the predicted climate change in tropical regions as it is likely to cause a considerable decline in the production of essential staple foods crops in such regions.

Climate inconsistency and change have always presented danger to food security in African countries through their effects on rainfall, soil moisture and production. It

directly affects agricultural production and food security given that most of the population in rural areas relies on agriculture for its livelihoods (Ochieng *et al*. 2016). Majority in Africa, especially smallholder farmers similar to the study area, are highly vulnerable to climatic and environmental hazards as they lack options to diversify their resources and income sources are limited. Their susceptibility is worsened by HIV/AIDS pandemic, lack of land access due to traditional land tenure systems, adequate water, poor technology, low level of education and institutional mismanagement (Nhemachena et al. 2010)

4.8.3 Livestock Production

Climate change impacts the amount and quality of production, reliability and natural resource base on which livestock production depends such as forage and continuous water availability. The TNP secondary data analysis done in relation to livestock incursion to the park in search of pasture and water over the past 15 years (Figure 4.8) revealed a tremendous annual increase. According to FGDs and key informants, pastoralists are supposed to keep fodder and water for their livestock during the dry season which normally happen between June to September and this is contributed by fluctuation of rainfall patterns.

Similarly, cattle incursion is much pronounced during these months as the pastoralists seems to suffer from water and pasture in villages adjacent the park. It is clearly observed that illegal livestock incursion is much higher now compared with trends over the past 10 years and probably due to prolonged drought contributed by climate change impacts.

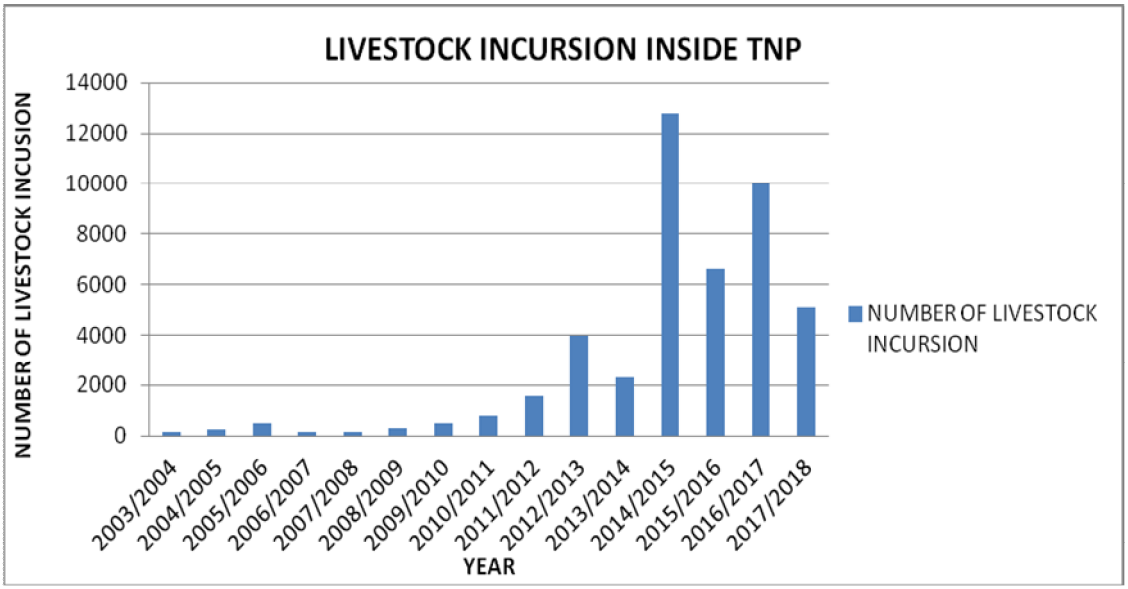

Figure 4.11: Trends of Livestock Incursion to TNP for the Past 15 Years
Source: TNP Data, 2018

Additionally, Baumgard *et al*. 2012 states that, livestock production globally faces increasing pressure as a result of negative environmental implications. Incidences of livestock diseases are likely to be affected by climate change since vectors development stages are often dependent on ambient temperature. On the other side, climate change will have far reaching impacts for livestock production systems that rely primarily on grass and rangelands and this will likely detrimentally affect vulnerable pastoral communities which are engaged in extensive livestock production systems in dry lands similar to TNP adjacent communities.

4.9 Summary of the Chapter

The results found that the majority of the respondents (65%) perceive climate change as drought and decrease in amount of rainfall. Also, 33% of the respondents mentioned deforestation as the major cause of climate change since the communities in the study areas use firewood and charcoal as the major source of fuel. Generally, large number of the respondents seemed to be aware of the climate change aspect

contributed by level of education, age and other interactions in their daily economic activities.

Weather trends of TNP were obtained by the analysis of data recorded from TNP Ecology department weather station and Internal Drainage Basin Water Board - Magugu weather station over the past 40 years from 1979 to 2017. Results showed insignificant decrease (R^2 =0.1798) in total annual rainfall by 17% at 95% confidence level. The decrease in rainfall amount, its distribution and variability over past 40 years was also commented by respondents during FGD and Key informant interviews as one of the climate change indicators within study areas. The respondents further reported that, in current years from 2015 they are receiving very small amounts of rainfall and sometimes they receive heavy rainfall within a short time of period which results to destruction of crops and infrastructure and then followed by prolonged drought.

The average monthly rainfall showed that, the area is characterized by semi-arid climate which have a prolonged dry condition with a bimodal rainfall type. The first short rainy season extends between September to December which locally called *'vuli'* with average rainfall ranging from 2mm to 117mm. The second-long rain season extends from January to May and locally known as *'masika'* with average rainfall ranging from 51mm to 114mm and dominated by cold weather with moderate temperature. However, the results from this study somehow does not concur with the results obtained from key informants and FGD since it was reported that short rains start from October to late December and usually in January the area does not receive rainfall until late February to May where it peaks and decline on

June.

The results found significant trends for mean maximum temperature on annual basis (R^2=0.5678) at 95% confidence level. On the other hand, insignificant trend was observed in mean minimum temperatures on annual basis where R^2=0.3378 at 95% confidence level. The existence of trends in maximum temperature supports the concern raised by respondents in FGD and Key informants that temperatures have been increasing over the past 30 years.

The status of food production has been decreasing over years. The study areas are dominated by agro-pastoralist the sense that they practice both small-scale farming and free-range livestock keeping. The main crop grown in the study areas is maize used as staple crop for food security and livelihood of small holder farmer. Trend of maize production has been declining yearly regardless of increasing rate of maize cultivation. Likewise, the production of livestock relies primarily on grass and rangelands which are highly affected by the climate change. Despite technological advances such as improved crop varieties, extension services and irrigation systems, weather and climate remain key factors in agricultural productivity.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents conclusion, recommendations and suggests areas for the further research within study areas.

5.2 Conclusions

Climate change is one of the greatest environmental, social and economic threats to the livelihood of communities in third world countries. The perceptions and impacts of climate change on communities' livelihoods adjacent to Tarangire National Parks is clearly discussed and presented in this dissertation. The majority of communities adjacent the park perceive drought and decrease in rainfall as the impacts of climate change. Also, they reported deforestation and agriculture activities as the major causes of climate change in their areas. On the other hand, they reported high temperature, shortened growing season and decrease in productivity as the indicators of climate change.

This study observed that, there is insignificant decrease in total annual rainfall, its distribution and variability over past 40 years by 17% since R^2 =0.1798 at 95% confidence level. On the other hand, this study found significant trends for mean maximum temperature on annual basis (R^2=0.5678) at 95% confidence level and insignificant trend on mean minimum temperatures on annual basis where R^2=0.3378 at 95% confidence level. The existence of trends in maximum temperature supports the concern raised by respondents in FGD and Key informants that temperatures have been increasing over the past 30 years.

Based on the trend of food production, the study concludes that most of the respondents in the study cultivate maize and beans as their main preferred staple food. However, the trend of maize production has been declining yearly due to decline in soil fertility, crops pest and pest diseases outbreak and poor farming practices. This was evidenced by the FGDs and key informant interview that production was significantly stable in previous years to sustain food supply but currently they need to import maize from other areas to meet food demand annually.

5.3 Recommendations

Having explored all the objectives, this study came up with the following recommendations:

Awareness raising and Capacity Building: Based on the study results and observation, central government intervention in reducing the risks associated with the impact and raising public awareness about climate change and associated livelihood impacts. There is the need for continuous education and awareness creation on climate change mitigation and adaptation mechanisms in the communities surrounding core protected areas. Raising awareness and building the capacity of communities around the park are vital tools for improving their understanding of the concept of climate change, its impacts and the capacity of the communities to effectively manage forest ecosystems and improve their livelihoods on sustainable basis.

Afforestation and Reforestation: Afforestation programs should be planned on a yearly basis so that local communities could initiate environmentally friendly activities and by planting trees in their farms which will ultimately help to improve

ecosystem services and mitigate the impacts of climate change. Forest restoration through re-forestation can help to remove greenhouse gasses from the atmosphere and also promote poverty alleviation, biodiversity conservation and improvement of ecosystem services provision.

Involvement of Local Communities in Resource Management: Improving governance and active participation of local communities in environmental decision making is very important to improve adaptation and livelihoods. Conservation and proper management of forests and ecosystem services is not possible without an active participation by the local communities. Community engagement will contribute to improving climate change policy outcomes by assisting community members to develop informed understanding of climate change trends, impacts, consequences and maximizing opportunities for citizens and communities to effectively contribute to public debate on climate change issues and actions.

5.4 Recommendation for Further Studies

This study has highlighted the impacts the impacts of climate change on the communitiesô livelihoods surrounding Tarangire National Park. It should be noted that there are still much to be researched concerning climate change impacts on the communitiesô livelihood. Whilst there is some literature on climate change some of them need further research including the following.

i. The assessment public awareness about local climate change impacts, in particularly drought and livestock diseases outbreak in Northern Tanzania.
ii. Assessment of the economic impacts of climate change to the pastoral community livelihoods and suggest possible adaptations strategies.

iii. Disaster management and resilience to the pastoral communities facing climate change impacts.

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APPENDICIES

7.1 Household Questionnaires

Villageé é é .....Wardé é é ..... Division.....é é Districté é é é ..

Section A: Demographic information

1. Respondent # ☐

2. Sex? Male ☐ Female ☐

3. Age in numbers

   18 -35 yrs ☐ 36 - 45 yrs ☐

   46 -60 yrs ☐ Over 60 yrs ☐

4. Education level;

   Primary level ☐ Certificate ☐ Degree ☐

   Secondary level ☐ Diploma level ☐ No education ☐

   Marital status: Single ☐ Married ☐ Separated ☐

   Widow ☐

   Divorced

5. Ethnicity of the household:

   Maasai ☐ Iraque ☐ Mbungwe ☐ Wagatoga ☐

   Warangi ☐ Others

   (Specify).....

6. For how long have you been in this village:- (Tick where appropriate)

   Below 5 years ☐ 6-10 Years ☐ Above 10 years ☐

7. What activities make you reside in this village? (tick where appropriate)

   Agriculture ☐ Livestock keeping ☐ Enterpreneurship ☐

   Family ☐ Marriage ☐ Employment ☐

   Favorable condition ☐ others

   (specify).....

8. What are the main economic activities for your household?

Section B: Community perceptions on climate change

B.1 What changes on weather patterns have you observed for the past 40 years since 1970 (*Probe for changes and tick where appropriate and add any others that the farmer mentions*)

S/N	Changes	Increasing	Decreasing	Fluctuating	No change	I donôt know
1	Temperature					
2	Rainfall					
3	Droughts/ long dry spells					
4	Rainfall variability					
5	Floods					
6	Late onset and early cessation of rainfall					

B.2 For the changes mentioned above, what are their impacts on your farming/ agriculture and household livelihoods in general?

1._____

2._____

3. _____

4._____

B.3 Of recent we have been hearing of climate change issues. In your understanding, what is climate change? Or how do you perceive climate change?

1. _____

2. _____

3. _____

4. _____

B.4 Are you aware that climate change is taking place in your area?

1. YES ☐ 2. NO ☐

B.5 Where did you learn / What are the sources of information that climate is changing? (*Tick as appropriate*)

S/N	**How did you know**	**YES**
1	Own observation	
2	Agricultural Extension officers	
3	Village meetings	
4	Fellow farmers	
5	Mass media (Radio, Television , Newspapers)	
6	Tanzania Meteorological Authority	
7	I donôt have any information	

B.6 How do you know that the climate is changing (indicators of climate change in your local area/ village)? (Tick *the appropriate responses*)

S/N	Indicators	YES	NO	DON'T KNOW
1	Lengthened growing seasons			
2	Shortened growing seasons			
3	Rainfall coming late in the seasons			
4	Rainfall coming too early in the seasons			
5	Increased rainfall amounts			
6	Decreased rainfall amounts			
7	Rainfall becoming unpredictable			
8	Increased incidences of drought			
9	Increased incidences of floods			
10	Increasing temperature			
11	Decreasing crop productivity			
12	Outbreak of Human diseases such as Malaria			
13	Outbreak of crop and animal pests and diseases			
14	Disappearance of some plant species (specify)			
15	Emergence of new plant species (specify them)			
16	Drying up of natural water springs			
17	Drying of natural streams and reduced river flows			
18	Others (specify)			

B.7 In your opinion, what do you think are the causes of climate change? (*Tick the appropriate responses*)

S/N	Cause of Climate change	Tick
1	Deforestation	
2	Keeping large number of livestock in an area	
3	Industrial activities	
4	Increased greenhouse gases in the atmosphere	
5	Use of biomass (firewood, charcoal)	
6	Use of fossil fuels	
7	Agricultural activities	
8	Gods plan	
9	I donȏt know	

B.8 What are the effects of Climate Change in your farming system? (*Tick the appropriate responses*)

S/N	Effects of climate change	Tick
1	Damaging crops and persistent low yields	
2	Reduction in pastures, livestock and milk	
3	Increase in livestock diseases	
4	Increase in crop pests and diseases	
5	Reduction in water sources	
6	Reduction in crop varieties and species	
7	Increase in non-farm and off-farm activities	
8	Increase in food shortages, hunger and poverty	
9	Others (specify)	

B.9 Which among the following is the most serious danger facing your community? (Rank from 5 & 4= Most serious, 3= Serious, 2 & 1= Least serious)

Threat	Ranking
Poverty	
Water shortage	
Climate change	
Population growth	
Diseases	

B.10 Where do you get information on weather forecast?

Source of information	Tick where appropriate
Television	
New paper	
Radio	
Social media (Facebook, whatsapp, twitter)	
Internet	
Studies	

B.11 Have you observed any significant changes in weather for the past 10 - 20 years?

Yes ☐ Not at all ☐

B.12 If yes which among the following (tick where appropriate)

Parameters	Tick where appropriate
Rainfall	
Crop yield	
Season shift	
Temperature	
Drought	
Floods	

Section C: Agricultural productivity trends

C.1 Do you own any farm land? Yes ☐ No ☐

C.2 If yes what is the size of the land? Tick where appropriate

Crops	Tick where appropriate
Less than 1 acre	
Between 1 - 5 acres	
Between 5 - 10 acres	
Above 10 acres	

C.3 How did you acquire the land you are occupying (i.e. means of land acquisition) ☐ ☐ ☐

Family land Village government Other Villagers

C.4 Which crop do you cultivate most? Rank 5 & 4 = Mostly prefered, 3 = prefered, 2 & 1 = Least prefered)

Crops	Ranking
Rice	
Maize	
Beans	
Sunflower	
Fruits and vegetables	

C.5 Which livestock species are mostly prefered by your community? Rank 5 & 4 = Mostly prefered, 3 = prefered, 2 & 1 = Least prefered)

Crops	Ranking
Cattle	
Goat	
Sheep	
Chicken	
Pig	
Others.....	

C.6 Can you estimate amount of crops harvested (maize) per acre for the past 15 years

Years	Quantity harvested	Reason
2017		
2012		
2007		
2002		

C.7 Generally, what is the historical pattern of crop productivity per acre in your farm?

1. Increasing ☐ 2. Decreasing ☐ 3.Flactuatring ☐

4. Dont know ☐ 5. No change ☐

C.8 Has there been any change in the types of crops/varieties grown by your household for the past 40 years?

Yes ☐ 2. No ☐

C.9 Mention the abandoned and new crop varieties grown and give reasons

S/N	New crop varieties grown	Abandoned crop varieties	Reason
1			
2			
3			
4			
5			
6			

C.10 Incase you donôt harvest anything due to prolonged drought (dry spell), what do you do to earn your living?

1._____

2. _____

7.2 Interview guide for key informants

Date: _____

Name of informant: _____ (upon introduction)

Position: _____

Note: Anything you tell me is confidential. Nothing you say will be personally attributed to you in any reports that result from this interview. All of our reports will be written in a manner that no individual comment can be attributed to a particular person.

Are you willing to answer my questions? Do you have any questions before we begin?

1. What challenges do you think farming sector as a whole is facing? (probe; What is causing, as you would dream of it, from happening? What is going on intensifying such challenges)
2. What needs to be done to help farmers to address the cahllenges? (Probe: Think back to the challenges we talked about in #1. What could be done about those?)
3. What do you think state agencies can and should do to help overcoming the existing challenges? (Probe: Assume you are head of the state, what do you think needs to be done)

4. Where are you currently getting information about climate change and its adaptation? (probe; which websites, meetings, training, in-person contacts, tv, radio etc)
5. In future, which is the best and easy way of conveying such information to community?
   (probe; which websites, meetings, training, in-person contacts, tv, radio etc)

7.3 Interview guide for focus group discussion

Date: _____

Group interviewed: _____

Interview completed by _____

Your participation in this focus group discussion is totally voluntary. Are you willing to answer our questions? _____

Do you have any questions before we begin? _____

1. Please talk briefly about challenges facing farming sector in your area?
2. Is a climate change a concern in your area? (probe to know which concern)
3. Is your community contributing to climate change? (probe to know more, how)
4. How did you first learn about climate change?
5. Are you aware of climate change adaptation? (probe to konw way of adaptation and how are they involved)
6. What needs improvement with regard to climate change?

Thank you for your time!